THE

PHOENIX FIRE DEPARTMENT

AND THE

ARIZONA AUTOMATIC FIRE ALARM ASSOCIATION

PRESENTS

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THE ACCURACY OF POINT-TO-POINT VOLTAGE DROP ON FIRE ALARM SYSTEMS

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Why are Fire Alarms Installed?

Millions of dollars are spent each year installing fire alarm systems. From the houses we live in, to the office buildings we work in. From the malls we shop in, to the stadiums we are entertained in. Fire alarm systems are all around us. As technology evolves, so does the complexity. Questions we have to ask include will they work? Will they protect our property? Will they alert us of an emergency with enough time to escape a burning building unharmed? Fire alarm systems are specified with these objectives in mind. So what can go wrong?

Fire alarm systems are included into building specifications for a number of reasons. Some of which include:

- Building and Fire Code requirements.
- Licensing agency requirements such as day care and health care.
- Insurance discounts, or insurance requirements.
- To satisfy Occupational Safety and Health Administration (OSHA) requirements for notification of employees.
- American with Disabilities Act (ADA) guidelines of notifying those who may not possess the same sensory detection as others.
- High-risk materials or processes.
- An employer's vested interest in extra protection for its employees and property.

For whatever reasons a system is specified, it must be able to perform. The laws of conservation provide that whatever goes in, must come out. However, if a system is not designed or installed appropriately, what comes out may not equal the expectations that went in. Experience has also shown that if the system is not thoroughly and regularly tested, usually by a third party such as an Authority Having Jurisdiction (AHJ) or an insurance evaluator, the owner might as well have invested their money into string and cans.

What Goes Wrong:

Although many systems are well designed in the beginning, any expansion or changes to the system can lead to failure. In order to gain a better appreciation of how simple changes can lead to disaster, lets look at two scenarios.

Scenario 1:

A new shell three story and non-sprinklered office building is being built which is equipped with a state of the art fire alarm system and notification devices. Because it is new, the tenant spaces have not been designed into the system. Soon, small tenants began to lease and build out their spaces. This particular AHJ does not require design documents (including voltage calculations) for small additions to the fire alarm system. As a result the contractor/designer fails to invest the extra effort to evaluate the existing system or impact of the new project. Purchase orders are issued and the contractor installs the

systems. When done, the installers initiate the circuit for a short time. There is sound, and the strobes flash. It looks good, so the installers go home.

The next tenant (located on the third floor) needs two devices installed. Because this is such a quick project, the contractor does not want to install and test the devices after hours or obtain an installation permit. Thus, they avoid creating a nuisance for the existing tenants by not setting off the alarms. So the devices are installed and the respective tenant moves in.

One month later, a fire starts in a first floor office space. A first floor tenant activates a fire alarm initiating device (pull station). However, only the notification appliances in a small section of the second floor operate. Many of the remaining occupants are not aware of the fire until the fire department shows up. By this time there is heavy smoke in the atrium style lobby and light smoke in the corridors of the building. Several occupants are overcome by smoke and require medical treatment. Taking the extra time to check the circuit voltage, evaluate the existing circuit loads, or calculating the new loads all could have avoided occupant injury and possibly reduced property loss.

Scenario 2:

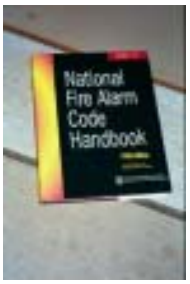
A fire alarm system is designed using point-to-point calculations (Note; with this design, it is very important the wiring and circuit path be installed in accordance with the approved plans). The contractor pulling the cable is used to running 110-volt AC circuits where wire route is generally not considered critical. Therefore, the cable is pulled to notification devices in no particular sequence, and not even to the devices calculated to be on the same circuit. Once all the devices are installed (usually the day before the tenant wants to occupy the space) an inspection is called for. Because of delays in getting the contracts signed and plans submitted, there has not been enough time to pre-test the system. The tenant is ready to move in, the inspector arrives, the system is activated, and the strobes flash. Once! Yes, the horns sound, but the strobes only flashed one time. What could be wrong?

Background:

Voltage drop is becoming a well-known problem in low-voltage, higher current circuits. For our purposes, higher current means in the range of amps as opposed to micro or milli amps. For the purpose of fire alarm design, this condition is especially critical on notification circuits. Such appliances include the more common horn/strobe devices as well as voice/speaker circuits. One reason for the elevated awareness of this issue results from the increased current-draw from brighter visual notification devices.

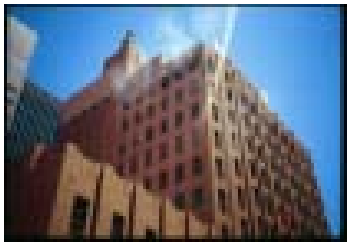
It is not the scope of this report to teach voltage drop calculation. Our scope is to evaluate test results of the different methods used in calculating the drop. However, if you do not have a basic understanding of how to calculate for voltage drop and the different methods available, then you will not understand how to apply the results of this project. As a result, we will try to explain it in the simplest form. Additional information on calculating voltage drop along with tips and tricks will be provided at the end of this report.

[1] *To guide designers and installers of fire alarm systems so that the system will deliver audible and visible information with appropriate intensity, the nameplate must state the capabilities of the appliance, as determined through tests conducted by the listing organization. The nameplate information also assists inspectors in verifying compliance with approved documents.*



Notification appliance circuits require special treatment to ensure that all the connected appliances will operate under adverse (low) voltage conditions. Low voltage, which is outside the operating range of the appliance, can cause the appliances to produce lower visible signal intensities or sound pressure levels (SPLs) {in many cases the strobes will fail all together}. Voltage at any appliance on the Notification Appliance Circuit (NAC) should not drop below the limits of the appliance design to ensure correct intensity and audibility. The designer of the notification appliance circuit should consider these interrelated questions: How many appliances can be connected to the NAC? What is the size of the field-wiring conductors? What is the total length of the NAC? It is therefore apparent that voltage drop calculations must be made.

[2] *There are several methods to calculate voltage drop for a circuit. The simplest is to calculate the entire load at the end of a class "B" circuit* (lump sum*) (See Figure 1). This approach should guarantee the system will work but will result in additional circuits and increased cost* (very conservative*). The most accurate method would be to calculate the actual losses between each device based on actual wire routing* (point-to-point*). This would make the most cost-effective use of the circuits and wire but has been considered time consuming and the wire is rarely run exactly as it was drawn on the plans. A third option is load centering where the entire load is calculated to be in the center of the circuit. This provides a rough average and works most of the time. A forth, but less common approach is to use current and distance averaging. Since the current difference between strobe only and horn/strobe is small (the strobes are the current hogs) this method distributes the load and any differences are 2-3 decimal places out.*



As with any calculation they must be used correctly to provide the accurate results. Load centering and load averaging work well unless the NAC is extremely long and/or the devices are not somewhat evenly placed. If the actual start of device placement is some distance from the power source (I.E., 300-ft underground run to another building) this will impact the calculation unless taken into account.

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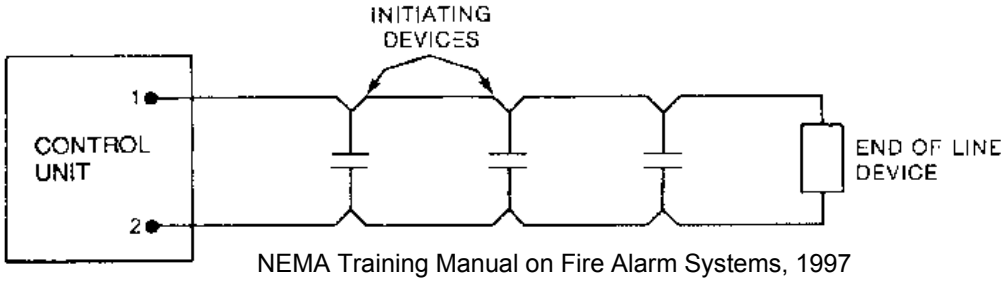
[1] Copied from the 1999 NFPA 72 (National Fire Alarm Code) Handbook p.p. 168.

[2] Extracted from "Indicating Device Appliance Circuits, Voltage Drop Facts & Fiction" by Arizona Automatic Fire Alarm Association August 12, 1998 Authored by Cliff Ehlers C.E.T

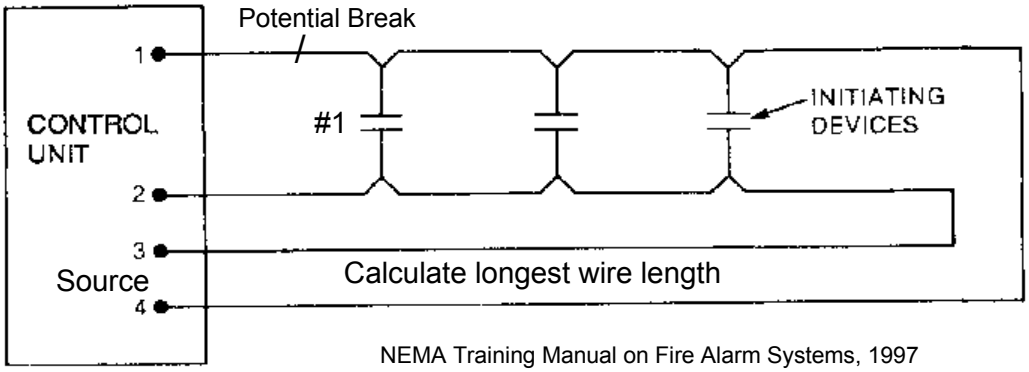


NEMA Training Manual on Fire Alarm Systems, 1997

Figure 1 - Class B Circuit

[2]*There are two ways to evaluate a class "A" circuit. Essentially you calculate it the same as a class "B" circuit. The only difference is establishing where to start. The correct method depends on how the wire is to be run for the circuit. First, is if the circuit starts at the source and goes through all the devices on the circuit. The circuit is then returned back to the source from the furthest end of the circuit. This would provide an extreme voltage drop concern if the break were at or close to terminals 1 or 2 (See Figure 2).* {In Figure 2, assuming a break between terminal 1 and device 1, start your measurement from terminal 3 and go through device 1 and back to terminal 4.} *All the circuit current would have to travel to the far end of the circuit then start powering devices on the return to the source. Thus, point-to-point calculations would have to start at points 3 & 4.*

A second way to run the circuit would be to make a loop with the devices connected as to distribute the load and create a circuit that is approximately equal in length and load from either end. In this case the voltage drop should be calculated from the end with the devices farthest from the source. {Similar to Figure 2, except that the load would be almost evenly distributed and you would calculate the longest length of the two.} It may be necessary to calculate both directions. This would be especially critical if using point-to-point calculations.



NEMA Training Manual on Fire Alarm Systems, 1997

Figure 2 - Class A Circuit

[2] Extracted from "Indicating Device Appliance Circuits, Voltage Drop Facts & Fiction" by Arizona Automatic Fire Alarm Association August 12, 1998 Authored by Cliff Ehlers C.E.T

Scope of Project:

This report summarizes the results of a voltage drop study that was conducted by the Phoenix Fire Department and the Arizona Automatic Fire Alarm Association during the summer of 2000. This stage of our study was limited to identifying the limits and accuracy of using point-to-point calculations for fire alarm horn/strobe notification circuits. In evaluating the accuracy of point-to-point calculations, comparisons are made to two other calculation methods (lump sum and center load).

How to Interpret the Results:

In order to document and evaluate the test results, a previously developed AZAFAA Microsoft Excel voltage drop calculator was modified (Figure 3). This spreadsheet allows for direct point-to-point entry of a notification circuit. In addition to providing point-to-point results, it provides lump sum and load-centering results. Thus, by entering the circuit once, we were able to obtain all three calculated results.

Project Name		Gentex (AFP-200 w/CBC - PL)				**POINT-POINT LIMITS MEET**			**Calculation method FAILED**			
Date												
Circuit Number		14-2 Using actual voltage				Standard Wire Resistance per 1000						
Notes		Battery power with no standby time				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			24.63	Actual = **see notes**		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.437		Wire	Ohm's	Alternate Calculations						
				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	435	3.838	1.437	435	1.919
	Listed	from	Voltage			Actual	1.575	435	4.207	1.575	435	2.103
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	23.75	0.88	3.58%	0.105	100	***23.52***	GXS			
Device 2	0.108	45	23.38	1.25	5.09%	0.110	45	***23.37***	GX-90S	Actual V drop of 2.67 / lump sum		
Device 3	0.093	10	23.30	1.33	5.40%	0.107	10	***23.16***	GXS	V drop of 4.21 = **+36% variation**:		
Device 4	0.108	15	23.20	1.43	5.83%	0.113	15	***23.06***	GX-90S	Actual V drop of 2.67 / load		
Device 5	0.093	30	23.00	1.63	6.60%	0.104	30	***22.88***	GXS	centering V drop of 2.10 = ***-27%***		
Device 6	0.108	25	22.86	1.77	7.19%	0.123	25	***22.73***	GX-90S	**variation**: using actual currents.		
Device 7	0.093	50	22.60	2.03	8.23%	0.106	50	***22.47***	GXS			
Device 8	0.108	20	22.51	2.12	8.60%	0.114	20	***22.37***	GX-90S			
Device 9	0.108	35	22.38	2.25	9.15%	0.115	35	***22.23***	GX-90S			
Device 10	0.108	10	22.34	2.29	9.28%	0.113	10	***22.20***	GX-90S			
Device 11	0.093	40	22.24	2.39	9.69%	0.111	40	***22.09***	GXS			
Device 12	0.108	30	22.18	2.45	9.94%	0.121	30	***22.01***	GX-90S			
Device 13	0.108	5	22.18	2.45	9.96%	0.118	5	***21.99***	GX-90S			
Device 14	0.108	20	22.16	2.47	10.02%	0.115	20	***21.96***	GX-90S			
END			22.16	2.47	10.02%							
END			22.16	2.47	10.02%							
END			22.16	2.47	10.02%							
END			22.16	2.47	10.02%							
END			22.16	2.47	10.02%							
END			22.16	2.47	10.02%							
Totals	1.437	435				1.575	435					
Actual voltage was 1% below calculated voltage throught test. Calculation method FAILED.												
Notes: Start voltage 24.63 at 1.63A, 8 minutes into test 24.39 volts at 1.63A, 16 minutes into test 24.35 volts at 1.62A.												

Figure 3 - Volt Drop Calculation Sheet

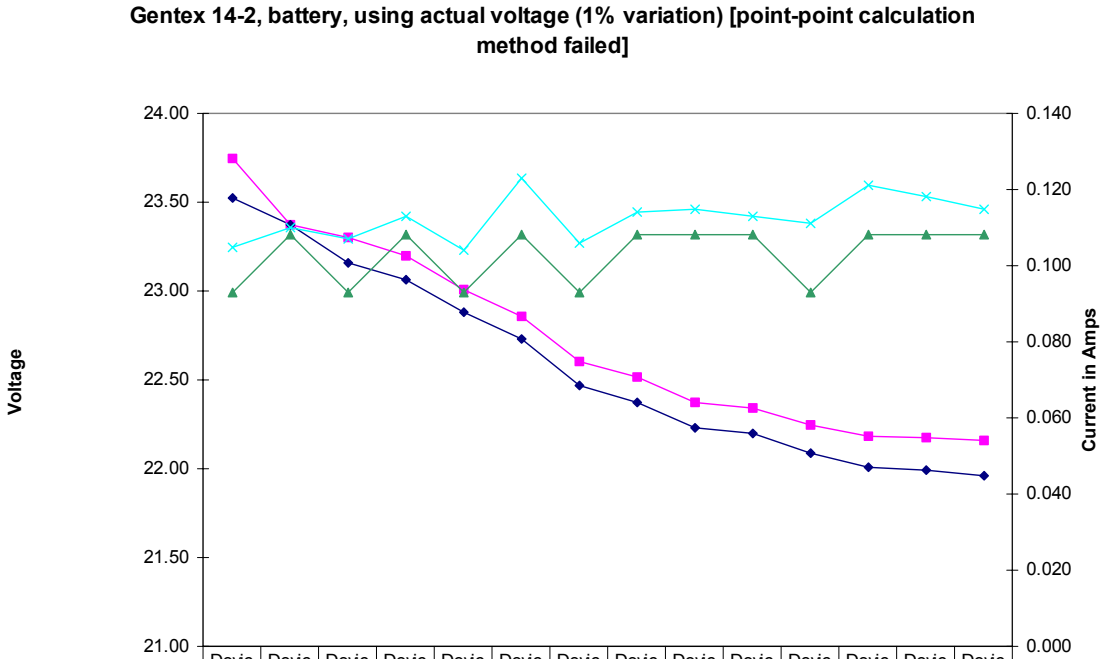
On the upper left section of the calculation (calc) sheet you will find some general information about the circuit. This includes:

- The project name, which is the device used in the test. This may include a power source model #.
- The circuit number, which is coded using the wire size and test number for that set of devices.
- The nominal and/or actual voltage used to base the calculation on (will vary by form).
  - Calculations were performed using the 'nominal" starting voltage of 24 volts DC or direct current as would be submitted for review. Then the "actual" voltage as measured at the power supply was inserted into the spreadsheet to more accurately evaluate the true voltage drop compared to the calculated voltage drop. This approach allows the reader to ascertain any potential cushion factor from a higher actual voltage versus a lower nominal voltage.
- The minimum device voltage, which is the minimum voltage listed in product specifications
- The total circuit current based on the sum of the listed device currents.
- An actual current which was measured by meter at the power supply.
- Wire size and distance. This sheet allows for one size wire from the source to first device, and for another size wire throughout the remainder of the circuit.
- Wire resistance per 1,000' is automatically calculated based on size (AWG) and is from the National Electrical Code (NEC) Chapter 9, Table 8. Actual manufacturer resistance could be entered and may be used to recalculate our tests at a later phase in this report. Actual wire resistance was measured and results can be found under the "validation of wire resistance" section later in this report.

The upper right section of the worksheet contains standard reference text and includes the alternate calculation methods. The top line also indicates results of the test. As an example, Figure 3 indicates that the "Point-Point Limits Meet." This text is automatically displayed by the formula within the spreadsheet. In this case, the calculated point-to-point voltage is above the device limits entered in the "Minimum Device Limit" field. However, the nest cell to the right indicates that the "calculation method failed." This text was manually entered to indicate that although the point-to-point limits were meet, the actual voltage drop was greater than the calculated voltage drop. Thus, the end of line voltage was lower than the design and therefore provided no safety factor. Alternate method fields are automatically calculated based on circuit information entered into the point-to-point fields making up the lower portion of the worksheet.

The lower left half of the worksheet consists of standard information found on the AZAFAA calculation sheet. The lower right half was added specifically for the purpose of this project. This allows the actual test measurements to be entered where they can be charted against the design measurements (Figure 4).

The calculation sheets representing the "actual source voltage" will include a note section on the right-center of the page indicating the percent of variation between the measured end-of-line voltage and the calculated voltages of lump sum and center load methods. This information on variance allows us to evaluate any potential safety factor between each calculation method. A note at the bottom of this sheet also indicates the percent variation between the actual versus the calculated point-to-point voltage. Again, the sheet in example 3 indicates the actual voltage was 1% below the calculated voltage.



	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10	Device 11	Device 12	Device 13	Device 14
Calc. voltage	23.75	23.38	23.30	23.20	23.00	22.86	22.60	22.51	22.38	22.34	22.24	22.18	22.18	22.16
Actual voltage	23.52	23.37	23.16	23.06	22.88	22.73	22.47	22.37	22.23	22.20	22.09	22.01	21.99	21.96
Listed current	0.093	0.108	0.093	0.108	0.093	0.108	0.093	0.108	0.108	0.108	0.093	0.108	0.108	0.108
Actual current	0.105	0.110	0.107	0.113	0.104	0.123	0.106	0.114	0.115	0.113	0.111	0.121	0.118	0.115

Figure 4 - Voltage Drop, Charted Result of One Test

Figure 4 graphically represents the point-to-point results for the calculations of Figure 3. The diamond (◆) and square (■) lines represent the actual field measured device voltage against the calculated device voltage respectively. While the "**X**" and triangular (▲) lines represent the actual field measured device current against the manufacturers advertised device current. As indicated on both "y" axis, the voltage is on the left, and the current in amps is on the right. The data summary across the bottom provides the actual numerical value for each data point indicated. It should be noted that the source voltage is not represented on the chart. All charted points start at device number 1. The actual and nominal voltages can be found on the respective data sheets (Figure 3).

The chart title provides a basic logic to the respective test. For example, the title in Figure 4 indicates that this test involved Gentex brand horn/strobe devices. The "14-2" indicates that this was the second design scenario using all 14 AWG (American Wire Gauge) cable. This test was conducted on battery power and was charted against the "actual" source voltage spreadsheet. The "actual" voltage charts will also indicate (in parentheses) the percent variation between the calculated voltage drop and the actual measured voltage drop. This is used to evaluate any potential safety factor within the point-to-point calculation method. **This percent variation is the backbone to our study in validating the accuracy of the point-to-point calculation method.** Throughout the report, the nominal source voltage calculations and charts will usually be presented ahead of the actual source voltage calculations and charts for each test.

Validation of Wire Resistance

A critical step in this study was to evaluate the actual wire resistance with respect to the wire resistance as published by the manufacturer and as provided in the 1999 National Electrical Code, Chapter 9, Table 8. The following table provides a comparison for various wire lengths. An important factor to consider is how the respective values were established. NEC values are based on a temperature of 75°C (167°F). Manufacturer values are established by averaging the resistance in continuous 1,000 foot sections of wire at 27°C (80°F). Our field measurements were made after joining various lengths of wire together with wire nuts. Most wire lengths ranged from 20' to 80'. We believe that such tests provided for a more accurate representation of field conditions. The wire nuts simulated actual field terminations to notification appliances. Resistance measurements could not be taken with the wire connected to the appliances as any extra resistance within the devices would not reflect wire-only resistance.

	18 AWG FPL, solid, copper			**14 AWG FPL, solid, copper**			**12 AWG, THHN, 19 strand**		
Wire Length	NEC	Mfg.	Actual	NEC	Mfg.	Actual	NEC	Mfg.	Actual
200'	1.55	1.3	1.4	0.61	0.52	0.5	0.40	0.35	0.4
400'	3.11	2.60	2.8	1.23	1.04	1.1	0.79	0.70	0.7
600'	4.66	3.90	4.2	1.84	1.56	1.6	1.19	1.04	1.1
800'	6.22	5.20	5.6	2.46	2.08	2.0	1.58	1.39	1.4
960'	7.46	6.24	6.8	-	-	-	-	-	-
1000'	7.77	6.50	-	3.07	2.60	2.6	1.98	1.74	1.8

NEC = National Electrical Code values from Chapter 9, Table 8, solid, uncoated (18AWG=7.77/kft, 14AWG=3.07/kft, 12AWG=1.98/kft). It should be noted that NEC values are based on elevated temperatures of 75°C (167°F).
Mfg. = Published values from the manufacturer (18AWG=6.50/kft, 14AWG=2.60/kft, 12AWG=1.74/kft.
Actual = Actual wire resistance measured in test without devices installed, including wire nut connections between variable lengths.

Figure 5 - Wire Resistance Values By Source (Ohm's)

Preliminary Interpretation of Test Results:

As of this preliminary draft copy, final conclusions have not been reached. Several tests including actual building tests have yet to be compiled. However, a few noticeable points can be made.

- The point-to-point method of calculating voltage drop using the wire resistance tables found in the NEC is extremely close when installed as designed. As you can see with the "validation of wire resistance" section, our field tests resulted in significantly higher resistance values then both NEC and Mfg. values. Noting that the manufacturers published resistance is lower than the NEC values there is valid concern that using the manufacturers published wire resistance figures may not provide satisfactory results. An important issue to consider was that our actual resistance values included various wire lengths connected with wire nuts to create the respective lengths. These results would therefore represent actual field installations including wire terminations at

devices, versus measuring one 1,000 foot continuous length of wire. For clarification, all wire was uncoiled during use in all of our tests.

- Using the conservative (higher) published currents is very important. Many manufacturers now publish the device current at each of three voltages. The upper specification voltage, the nominal voltage, and the minimum specification voltage (i.e. 30vdc, 24vdc, 20vdc). The higher current, which corresponds to the lower voltage, should be used. It is important to note that as voltage decreases, current increases. This is defined by Ohm's Law of I=V/R and was validated in our tests as represented on the charts.
- The effect of running alarms off of batteries, versus running alarms off of primary power does have an impact. All system tests should be conducted on battery power and voltage readings taken. Battery life and voltage must be considered in designing a system. However, at this time and pending further testing which was not a part of this project, it is not the authors' opinion that battery life should be compensated for in voltage drop calculations. That is, we should not compensate for bad batteries in our voltage drop design. Safety factors for batteries should be incorporated into the standby battery calculations.
- Wire size plays a critical role in the limits of a circuit. Careful consideration should be used in determining wire size. The author recommends that 14 AWG and 12 AWG wires be used conservatively. Larger gauge wire should be used for long home runs reducing voltage loss from resistance.

How to Use the Information:

It is the objective of this report to provide sufficient information so that the user can learn from, and appreciate the efforts of this project. We hope that this information will help each individual involved in the design and installation of fire alarm systems to better understand the evaluation and impact of voltage drop.

Our tests validate the accuracy of Ohm's Law. We have validated the accuracy of point-to-point calculations. We confirmed our suspicion that lump sum calculations are conservative and do provide a significant margin of safety for the initially calculated system. However, this margin of safety can be significantly compromised when additional devices are added to a circuit without performing new calculations.

If point-to-point calculations are to be used, it is imperative that designers thoroughly evaluate the exact routing that the wire shall be installed. Installers must not deviate wire routing in a manner that will increase the wire resistance of a circuit.

As margins of safety continue to be narrowed through such approaches as performance based design and value engineering, early and effective notification of occupants will become more critical. Authorities Having Jurisdiction must require that field measurements be conducted as part of any system inspection. All such inspection must be conducted using the lowest voltage power source for the system. In most cases this will be the standby batteries. However, if the systems secondary power supply is generators, this voltage could be slightly higher or lower than the primary power supply. This will also depend on regulated power supply of the fire alarm system.

A Few Results:

The calculation sheets and charts included in this report represent tests that were conducted. A few tests are still being evaluated and may not be included. The final report will incorporate the results of all tests conducted. Although some tests were identified as inconclusive for drawing conclusions, they were still able to validate the accuracy of the point-to-point calculation method.

These tests only provide validation to one issue involving fire alarm systems. Some additional testing that we would like to see conducted includes:

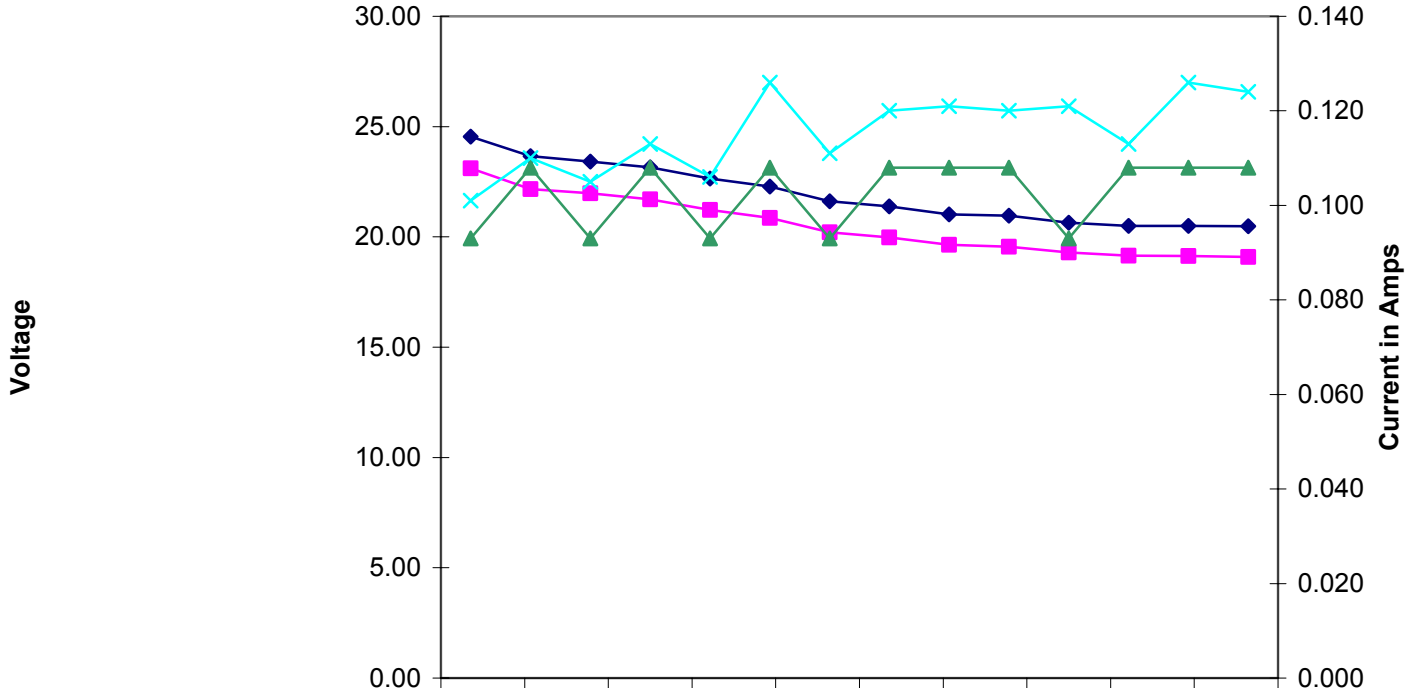
- Voltage and resistance drop evaluation on speaker circuits.
- Battery life.
- Additional evaluation of circuit design versus real-life installation.
- Temperature effects on circuit resistance and components (outdoor installations).

A description of the test procedures is included at the end of the report.

Excel Sheets and Charts

Project Name		Gentex										
Date		July 18, 2000				**EXCEEDS DEVICE LIMITS**						
Circuit Number		18-1				Standard Wire Resistance per 1000						
Notes		110vac, Solid tone, strobes not synched				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = 25.60		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.437		Wire	Ohm's	Alternate Calculations						
Actual current 1.66				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			40	18	7.77		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				18	7.77		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	375	8.374	1.437	375	4.187
	Listed	from	Voltage			Actual	1.617	375	9.423	1.617	375	4.712
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	40	23.11	0.89	3.72%	0.10	40.00	24.55	GXS			
Device 2	0.108	45	22.17	1.83	7.64%	0.11	45.00	23.66	GX-90S			
Device 3	0.093	10	21.97	2.03	8.44%	0.11	10.00	23.42	GXS			
Device 4	0.108	15	21.71	2.29	9.55%	0.11	15.00	23.15	GX-90S			
Device 5	0.093	30	21.23	2.77	11.56%	0.11	30.00	22.65	GXS			
Device 6	0.108	25	20.86	3.14	13.08%	0.13	25.00	22.28	GX-90S			
Device 7	0.093	50	20.21	3.79	15.78%	0.11	50.00	21.62	GXS			
Device 8	0.108	20	19.98	4.02	16.74%	0.12	20.00	21.39	GX-90S			
Device 9	0.108	35	19.64	4.36	18.18%	0.12	35.00	21.02	GX-90S			
Device 10	0.108	10	19.56	4.44	18.52%	0.12	10.00	20.96	GX-90S			
Device 11	0.093	40	19.30	4.70	19.60%	0.12	40.00	20.65	GXS			
Device 12	0.108	30	19.15	4.85	20.23%	0.11	30.00	20.50	GX-90S			
Device 13	0.108	5	19.13	4.87	20.30%	0.13	5.00	20.50	GX-90S			
Device 14	0.108	20	19.10	4.90	20.44%	0.12	20.00	20.49	GX-90S			
END			19.10	4.90	20.44%							
END			19.10	4.90	20.44%							
END			19.10	4.90	20.44%							
END			19.10	4.90	20.44%							
END			19.10	4.90	20.44%							
END			19.10	4.90	20.44%							
Totals	1.437	375				1.617	375					

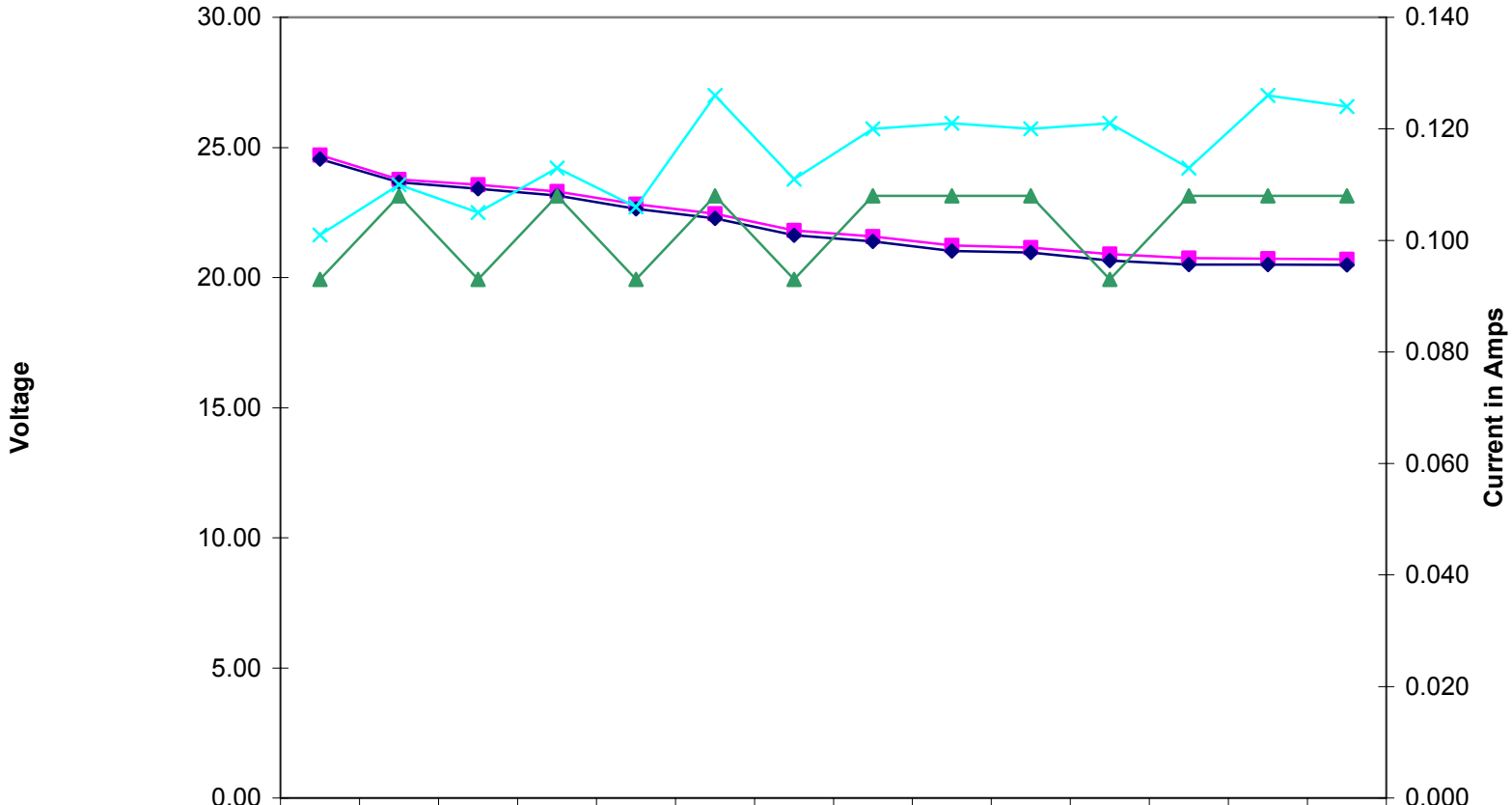
Gentex 18/1 using nominal voltage



	Device 1	Device 2	Device 4	Device 5	Device 7	Device 8	Device 9	Device 11	Device 12	Device 14
Calculated voltage	23.11	22.17	21.71	21.23	20.21	19.98	19.64	19.30	19.15	19.10
Actual measured voltage	24.55	23.66	23.15	22.65	21.62	21.39	21.02	20.65	20.50	20.49
Manufacturer listed current	0.093	0.108	0.108	0.093	0.093	0.108	0.108	0.093	0.108	0.108
Actual measured current	0.10	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.11	0.12

Project Name		Gentex											
Date		July 18, 2000				**EXCEEDS DEVICE LIMITS**			**Point to Point Calculation method FAILED**				
Circuit Number		18-1 using actual voltage				Standard Wire Resistance per 1000							
Notes		110vac, Solid tone, strobes not synched				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24			
Actual System Voltage			25.6			When entering your measured value. Use the resistance measured for							
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back							
Total Circuit Current		1.437		Wire	Ohm's	Alternate Calculations							
Actual current 1.66				Gauge	Per 1000		Lump-Sum Method			Load Centering Method			
Distance from source to 1st device			40	18	7.77		Totals		Voltage	Totals		Voltage	
Wire Gauge for balance of circuit				18	7.77		Current	Distance	Drop	Current	Distance	Drop	
		Distance				Calculated	1.437	375	8.374	1.437	375	4.187	
	Listed	from	Voltage			Actual	1.617	375	9.423	1.617	375	4.712	
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex		
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:				
Device 1	0.093	40	24.71	0.89	3.49%	0.10	40.00	24.55	GXS				
Device 2	0.108	45	23.77	1.83	7.16%	0.11	45.00	23.66	GX-90S	Actual V drop of 5.11 / lump sum			
Device 3	0.093	10	23.57	2.03	7.91%	0.11	10.00	23.42	GXS	V drop of 9.42 = **+46% variation**:			
Device 4	0.108	15	23.31	2.29	8.95%	0.11	15.00	23.15	GX-90S	Actual V drop of 5.11 / load			
Device 5	0.093	30	22.83	2.77	10.84%	0.11	30.00	22.65	GXS	centering V drop of 4.71 = ***--8%***			
Device 6	0.108	25	22.46	3.14	12.27%	0.13	25.00	22.28	GX-90S	**variation**: using actual currents.			
Device 7	0.093	50	21.81	3.79	14.80%	0.11	50.00	21.62	GXS				
Device 8	0.108	20	21.58	4.02	15.70%	0.12	20.00	21.39	GX-90S				
Device 9	0.108	35	21.24	4.36	17.04%	0.12	35.00	21.02	GX-90S				
Device 10	0.108	10	21.16	4.44	17.36%	0.12	10.00	20.96	GX-90S				
Device 11	0.093	40	20.90	4.70	18.37%	0.12	40.00	20.65	GXS				
Device 12	0.108	30	20.75	4.85	18.96%	0.11	30.00	20.50	GX-90S				
Device 13	0.108	5	20.73	4.87	19.03%	0.13	5.00	20.50	GX-90S				
Device 14	0.108	20	20.70	4.90	19.16%	0.12	20.00	20.49	GX-90S				
END			20.70	4.90	19.16%								
END			20.70	4.90	19.16%								
END			20.70	4.90	19.16%								
END			20.70	4.90	19.16%								
END			20.70	4.90	19.16%								
END			20.70	4.90	19.16%								
Totals	1.437	375				1.617	375						
Actual voltage was under the calculated voltage by 1%. Point to Point calculation method FAILED.													

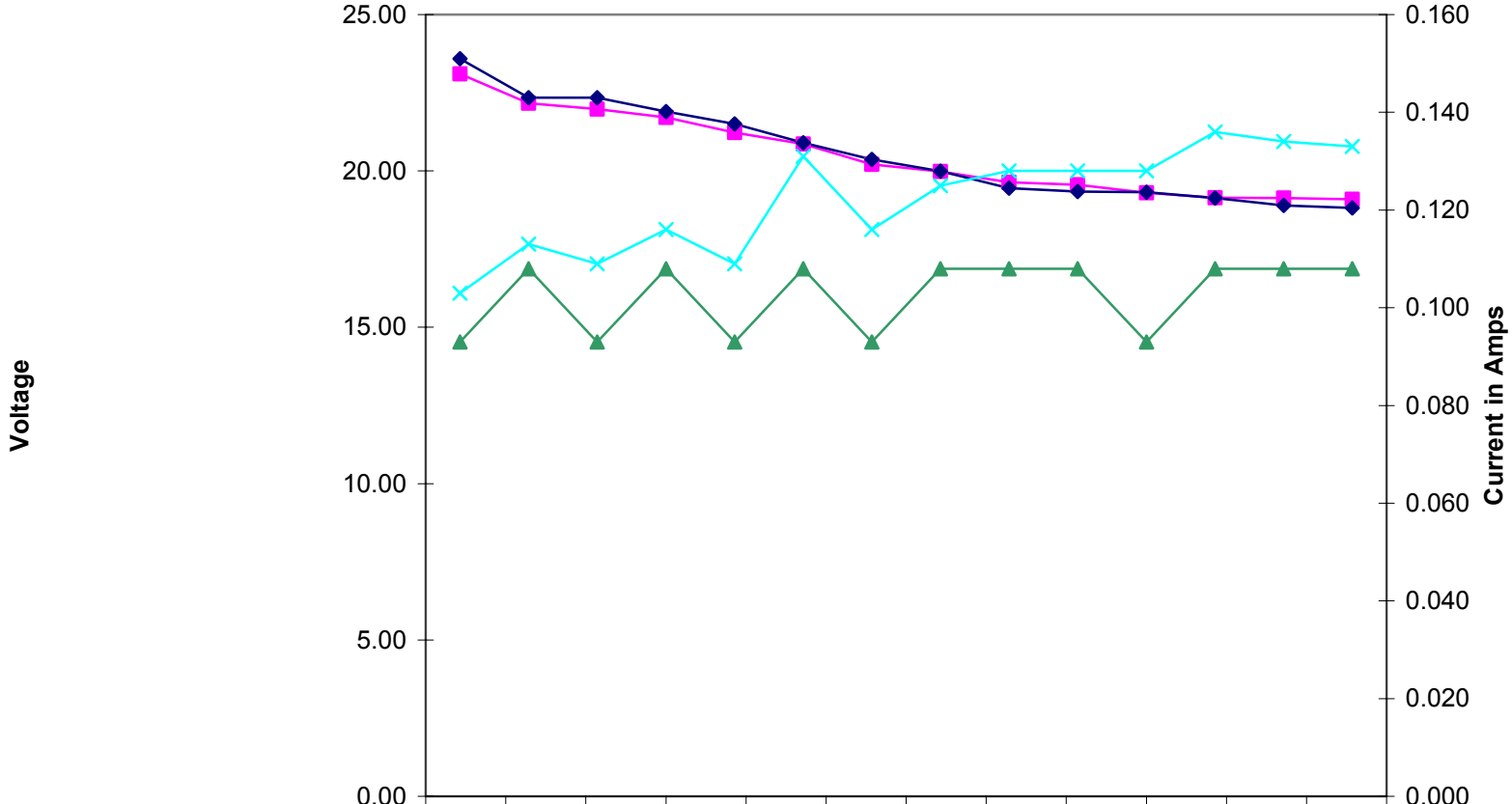
Gentex 18-1 using actual voltage (Calculation failed by a 1% variation)



	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10	Device 11	Device 12	Device 13	Device 14
Calc. voltage	24.71	23.77	23.57	23.31	22.83	22.46	21.81	21.58	21.24	21.16	20.90	20.75	20.73	20.70
Actual voltage	24.55	23.66	23.42	23.15	22.65	22.28	21.62	21.39	21.02	20.96	20.65	20.50	20.50	20.49
Listed current	0.093	0.108	0.093	0.108	0.093	0.108	0.093	0.108	0.108	0.108	0.093	0.108	0.108	0.108
Actual current	0.10	0.11	0.11	0.11	0.11	0.13	0.11	0.12	0.12	0.12	0.12	0.11	0.13	0.12

Project Name		Gentex										
Date		July 18, 2000				**EXCEEDS DEVICE LIMITS**						
Circuit Number		18-2				Standard Wire Resistance per 1000						
Notes		Battery power with no standby time				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = 24.47		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.437		Wire	Ohm's	Alternate Calculations						
				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			40	18	7.77		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				18	7.77		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	375	8.374	1.437	375	4.187
	Listed	from		Voltage		Actual	1.709	375	9.959	1.709	375	4.980
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	40	23.11	0.89	3.72%	0.103	40.00	23.59	GXS			
Device 2	0.108	45	22.17	1.83	7.64%	0.113	45.00	22.34	GX-90S			
Device 3	0.093	10	21.97	2.03	8.44%	0.109	10.00	22.34	GXS			
Device 4	0.108	15	21.71	2.29	9.55%	0.116	15.00	21.90	GX-90S			
Device 5	0.093	30	21.23	2.77	11.56%	0.109	30.00	21.50	GXS			
Device 6	0.108	25	20.86	3.14	13.08%	0.131	25.00	20.90	GX-90S			
Device 7	0.093	50	20.21	3.79	15.78%	0.116	50.00	20.37	GXS			
Device 8	0.108	20	19.98	4.02	16.74%	0.125	20.00	19.99	GX-90S			
Device 9	0.108	35	19.64	4.36	18.18%	0.128	35.00	19.45	GX-90S			
Device 10	0.108	10	19.56	4.44	18.52%	0.128	10.00	19.34	GX-90S			
Device 11	0.093	40	19.30	4.70	19.60%	0.128	40.00	19.32	GXS			
Device 12	0.108	30	19.15	4.85	20.23%	0.136	30.00	19.13	GX-90S			
Device 13	0.108	5	19.13	4.87	20.30%	0.134	5.00	18.90	GX-90S			
Device 14	0.108	20	19.10	4.90	20.44%	0.133	20.00	18.82	GX-90S			
END			19.10	4.90	20.44%							
END			19.10	4.90	20.44%							
END			19.10	4.90	20.44%							
END			19.10	4.90	20.44%							
END			19.10	4.90	20.44%							
END			19.10	4.90	20.44%							
Totals	1.437	375				1.709	375					
Addit. Notes: Start voltage at panel = 24.47, eight minutes into test = 24.35vdc, at end of test 16 minutes = 24.13vdc at 1.83amps.												

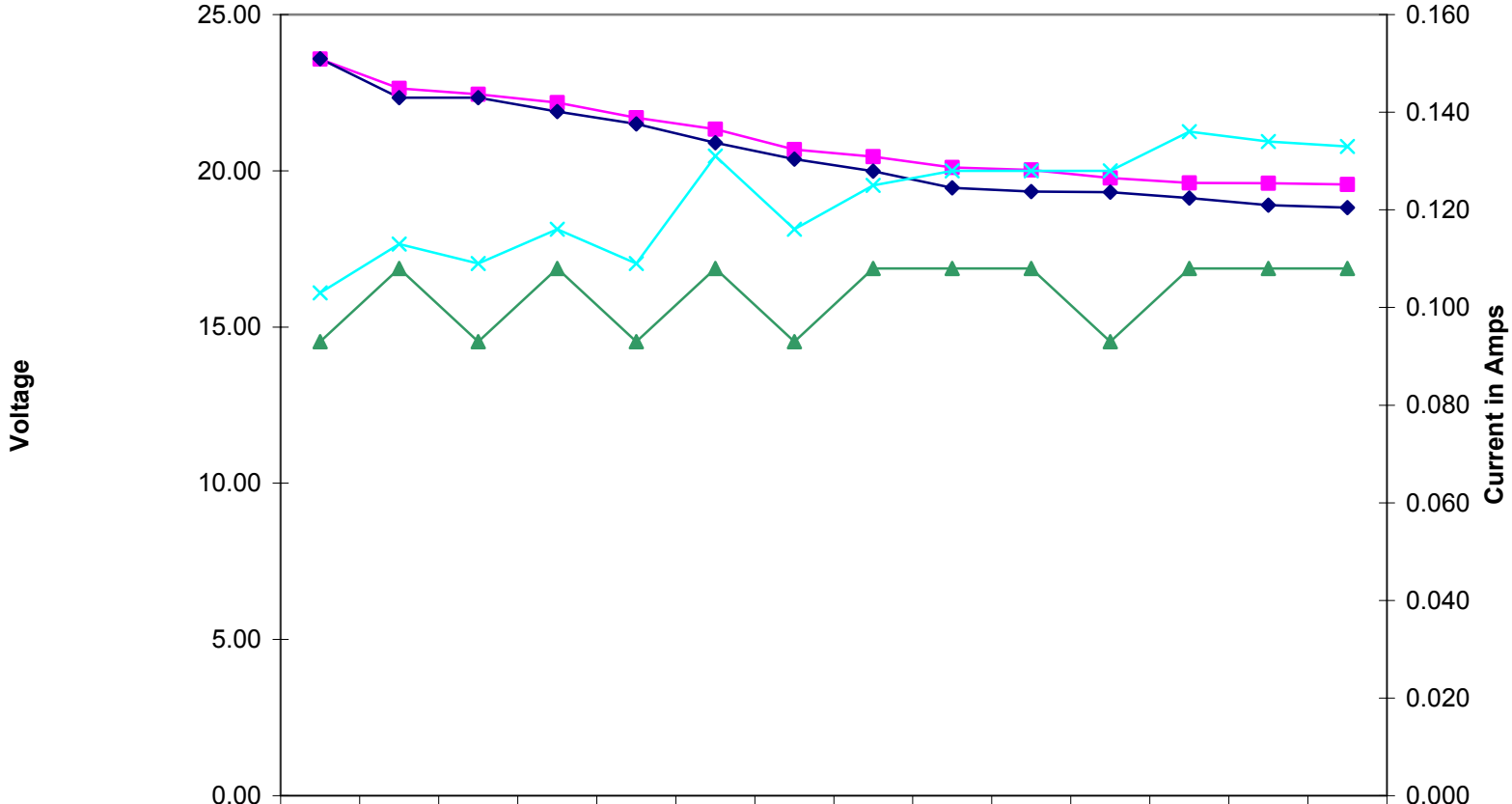
Gentex 18/2, using nominal voltage



	Device 1	Device 2	Device 3	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10	Device 12	Device 13	Device 14
Calculated voltage	23.11	22.17	21.97	21.23	20.86	20.21	19.98	19.64	19.56	19.15	19.13	19.10
Actual measured voltage	23.59	22.34	22.34	21.50	20.90	20.37	19.99	19.45	19.34	19.13	18.90	18.82
Manufacturer listed current	0.093	0.108	0.093	0.093	0.108	0.093	0.108	0.108	0.108	0.108	0.108	0.108
Actual measured current	0.103	0.113	0.109	0.109	0.131	0.116	0.125	0.128	0.128	0.136	0.134	0.133

Project Name		Gentex										
Date		July 18, 2000				**EXCEEDS DEVICE LIMITS**			**Point to Point Calculation Considered FAILED**			
Circuit Number		18-2 using actual voltage				Standard Wire Resistance per 1000						
Notes		Battery power with no standby time				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			24.47	Actual=see notes		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.437		Wire	Ohm's	Alternate Calculations						
				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			40	18	7.77		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				18	7.77		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	375	8.374	1.437	375	4.187
	Listed	from	Voltage			Actual	1.709	375	9.959	1.709	375	4.980
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	40	23.58	0.89	3.65%	0.103	40.00	23.59	GXS			
Device 2	0.108	45	22.64	1.83	7.49%	0.113	45.00	22.34	GX-90S	Actual V drop of 5.65 / lump sum		
Device 3	0.093	10	22.44	2.03	8.28%	0.109	10.00	22.34	GXS	V drop of 9.96 = **+43% variation**:		
Device 4	0.108	15	22.18	2.29	9.36%	0.116	15.00	21.90	GX-90S	Actual V drop of 5.65 / load		
Device 5	0.093	30	21.70	2.77	11.34%	0.109	30.00	21.50	GXS	centering V drop of 4.98 = ***--13%***		
Device 6	0.108	25	21.33	3.14	12.83%	0.131	25.00	20.90	GX-90S	***variation*** : using actual currents.		
Device 7	0.093	50	20.68	3.79	15.48%	0.116	50.00	20.37	GXS			
Device 8	0.108	20	20.45	4.02	16.42%	0.125	20.00	19.99	GX-90S			
Device 9	0.108	35	20.11	4.36	17.83%	0.128	35.00	19.45	GX-90S			
Device 10	0.108	10	20.03	4.44	18.16%	0.128	10.00	19.34	GX-90S			
Device 11	0.093	40	19.77	4.70	19.22%	0.128	40.00	19.32	GXS			
Device 12	0.108	30	19.62	4.85	19.84%	0.136	30.00	19.13	GX-90S			
Device 13	0.108	5	19.60	4.87	19.91%	0.134	5.00	18.90	GX-90S			
Device 14	0.108	20	19.57	4.90	20.04%	0.133	20.00	18.82	GX-90S			
END			19.57	4.90	20.04%							
END			19.57	4.90	20.04%							
END			19.57	4.90	20.04%							
END			19.57	4.90	20.04%							
END			19.57	4.90	20.04%							
END			19.57	4.90	20.04%							
Totals	1.437	375				1.709	375					
Actual voltage started at 0% varience and immediately went below calculated to a variance of 4%. Calculation considered FAILED.												
Addit. Notes: Start voltage at panel = 24.47, eight minutes into test = 24.35vdc, at end of test 16 minutes = 24.13vdc at 1.83amps.												

Gentex 18-2, battery, using actual voltage (Failed by 3% variation)



	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10	Device 11	Device 12	Device 13	Device 14
Calc. voltage	23.58	22.64	22.44	22.18	21.70	21.33	20.68	20.45	20.11	20.03	19.77	19.62	19.60	19.57
Actual voltage	23.59	22.34	22.34	21.90	21.50	20.90	20.37	19.99	19.45	19.34	19.32	19.13	18.90	18.82
Listed current	0.093	0.108	0.093	0.108	0.093	0.108	0.093	0.108	0.108	0.108	0.093	0.108	0.108	0.108
Actual current	0.103	0.113	0.109	0.116	0.109	0.131	0.116	0.125	0.128	0.128	0.128	0.136	0.134	0.133

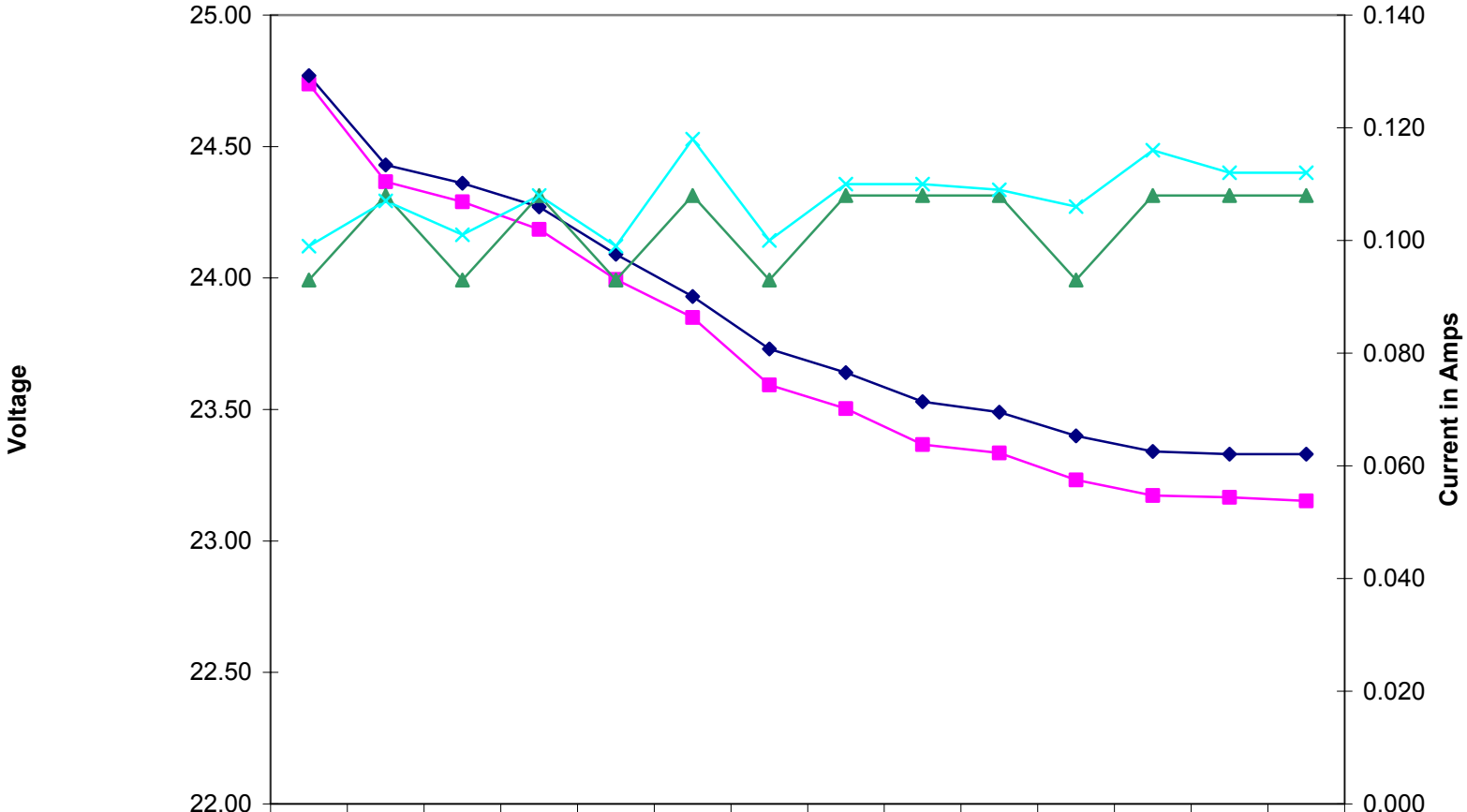
Project Name		Gentex										
Date		July 18, 2000				**EXCEEDS DEVICE LIMITS**			**Point to Point calculation FAILED**			
Circuit Number		18-3 Using actual voltage				Standard Wire Resistance per 1000						
Notes		Configuration of 18-1 with 100' home run				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			25.5			When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.437		Wire	Ohm's	Alternate Calculations						
				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	18	7.77		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				18	7.77		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	435	9.714	1.437	435	4.857
	Listed	from	Voltage			Actual	*	435	#VALUE!	*	435	#VALUE!
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	23.27	2.23	8.76%	0.104	100.00	23.17	GXS			
Device 2	0.108	45	22.33	3.17	12.44%		45.00		GX-90S	Actual V drop of 6.78 was not		
Device 3	0.093	10	22.13	3.37	13.20%		10.00		GXS	compared to lump sum or load		
Device 4	0.108	15	21.87	3.63	14.24%		15.00		GX-90S	centering since all actual current		
Device 5	0.093	30	21.39	4.11	16.13%		30.00		GXS	readings were not taken. This		
Device 6	0.108	25	21.02	4.48	17.57%		25.00		GX-90S	test was done to compare extra		
Device 7	0.093	50	20.37	5.13	20.11%		50.00		GXS	resistance of home run with		
Device 8	0.108	20	20.14	5.36	21.01%		20.00		GX-90S	respect to circuit 18-2. **No chart**		
Device 9	0.108	35	19.80	5.70	22.36%		35.00		GX-90S	**was generated for this test.**		
Device 10	0.108	10	19.72	5.78	22.68%		10.00		GX-90S			
Device 11	0.093	40	19.46	6.04	23.70%		40.00		GXS			
Device 12	0.108	30	19.31	6.19	24.29%		30.00		GX-90S			
Device 13	0.108	5	19.29	6.21	24.36%		5.00		GX-90S			
Device 14	0.108	20	19.26	6.24	24.49%	0.133	20.00	18.72	GX-90S			
END			19.26	6.24	24.49%							
END			19.26	6.24	24.49%							
END			19.26	6.24	24.49%							
END			19.26	6.24	24.49%							
END			19.26	6.24	24.49%							
END			19.26	6.24	24.49%							
Totals	1.437	435				*	435					
						*Actual measured current total = 1.82A						
Actual voltage went below calculated by 3% variation. Point to Point calculation Failed.												

<u>No Chart for This Sheet.</u>

Circuit 18-3 is similar to 18-1.
Exception: 18-3 has 100' home run causing its actual end of line voltage to be 3% below calculated.
Circuit 18-1 with a 40' home run had an actual end of line voltage of 1% below calculated.

Project Name		Gentex (AFP-200 w/CBC - PL)				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14-1 (compare to Gentex 18-3 & 18-4) Actual				Standard Wire Resistance per 1000						
Notes		110 vac, solid tone, strobes not synched				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			25.62			When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.437		Wire	Ohm's	Alternate Calculations						
Total actual current = 1.55A				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	435	3.838	1.437	435	1.919
	Listed	from	Voltage			Actual	1.507	435	4.025	1.507	435	2.013
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	24.74	0.88	3.44%	0.099	100	24.77	GXS			
Device 2	0.108	45	24.37	1.25	4.89%	0.107	45	24.43	GX-90S	Actual V drop of 2.29 / lump sum		
Device 3	0.093	10	24.29	1.33	5.19%	0.101	10	24.36	GXS	V drop of 4.00 = **+43% variation**:		
Device 4	0.108	15	24.19	1.43	5.60%	0.108	15	24.27	GX-90S	Actual V drop of 2.29 / load		
Device 5	0.093	30	23.99	1.63	6.34%	0.099	30	24.09	GXS	centering V drop of 2.01 = **+14%**		
Device 6	0.108	25	23.85	1.77	6.91%	0.118	25	23.93	GX-90S	**variation**: using actual currents.		
Device 7	0.093	50	23.59	2.03	7.91%	0.100	50	23.73	GXS			
Device 8	0.108	20	23.50	2.12	8.26%	0.110	20	23.64	GX-90S			
Device 9	0.108	35	23.37	2.25	8.79%	0.110	35	23.53	GX-90S			
Device 10	0.108	10	23.33	2.29	8.92%	0.109	10	23.49	GX-90S			
Device 11	0.093	40	23.23	2.39	9.32%	0.106	40	23.40	GXS			
Device 12	0.108	30	23.17	2.45	9.55%	0.116	30	23.34	GX-90S			
Device 13	0.108	5	23.17	2.45	9.58%	0.112	5	23.33	GX-90S			
Device 14	0.108	20	23.15	2.47	9.63%	0.112	20	23.33	GX-90S			
END			23.15	2.47	9.63%							
END			23.15	2.47	9.63%							
END			23.15	2.47	9.63%							
END			23.15	2.47	9.63%							
END			23.15	2.47	9.63%							
END			23.15	2.47	9.63%							
Totals	1.437	435				1.507	435					
Actual voltage is above calculated by <1%.												

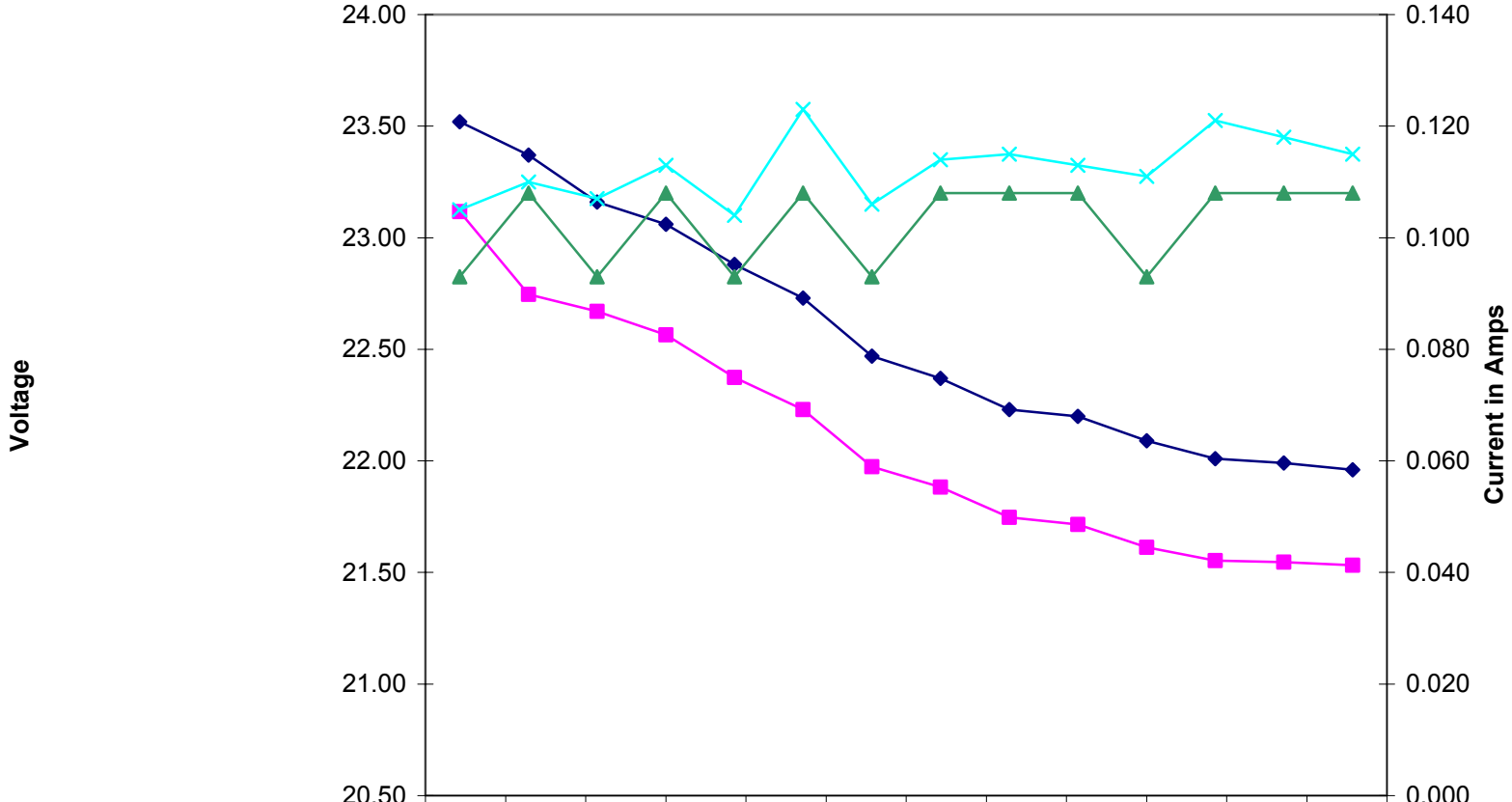
Gentex 14-1 using actual voltage (<1% variation)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Calc. voltage	24.74	24.37	24.29	24.19	23.99	23.85	23.59	23.50	23.37	23.33	23.23	23.17	23.17	23.15
Actual voltage	24.77	24.43	24.36	24.27	24.09	23.93	23.73	23.64	23.53	23.49	23.40	23.34	23.33	23.33
Listed current	0.093	0.108	0.093	0.108	0.093	0.108	0.093	0.108	0.108	0.108	0.093	0.108	0.108	0.108
Actual current	0.099	0.107	0.101	0.108	0.099	0.118	0.100	0.110	0.110	0.109	0.106	0.116	0.112	0.112

Project Name		Gentex (AFP-200 w/CBC - PL)				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14-2				Standard Wire Resistance per 1000						
Notes		Batterypower with no standby time				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = see notes		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.437		Wire	Ohm's	Alternate Calculations						
				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	435	3.838	1.437	435	1.919
	Listed	from	Voltage			Actual	1.575	435	4.207	1.575	435	2.103
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	23.12	0.88	3.68%	0.105	100	23.52	GXS			
Device 2	0.108	45	22.75	1.25	5.22%	0.110	45	23.37	GX-90S			
Device 3	0.093	10	22.67	1.33	5.54%	0.107	10	23.16	GXS			
Device 4	0.108	15	22.57	1.43	5.98%	0.113	15	23.06	GX-90S			
Device 5	0.093	30	22.37	1.63	6.77%	0.104	30	22.88	GXS			
Device 6	0.108	25	22.23	1.77	7.38%	0.123	25	22.73	GX-90S			
Device 7	0.093	50	21.97	2.03	8.44%	0.106	50	22.47	GXS			
Device 8	0.108	20	21.88	2.12	8.82%	0.114	20	22.37	GX-90S			
Device 9	0.108	35	21.75	2.25	9.39%	0.115	35	22.23	GX-90S			
Device 10	0.108	10	21.71	2.29	9.52%	0.113	10	22.20	GX-90S			
Device 11	0.093	40	21.61	2.39	9.95%	0.111	40	22.09	GXS			
Device 12	0.108	30	21.55	2.45	10.20%	0.121	30	22.01	GX-90S			
Device 13	0.108	5	21.55	2.45	10.23%	0.118	5	21.99	GX-90S			
Device 14	0.108	20	21.53	2.47	10.28%	0.115	20	21.96	GX-90S			
END			21.53	2.47	10.28%							
END			21.53	2.47	10.28%							
END			21.53	2.47	10.28%							
END			21.53	2.47	10.28%							
END			21.53	2.47	10.28%							
END			21.53	2.47	10.28%							
Totals	1.437	435				1.575	435					
Notes: Start voltage 24.63 at 1.63A, 8 minutes into test 24.39 volts at 1.63A, 16 minutes into test 24.35 volts at 1.62A.												

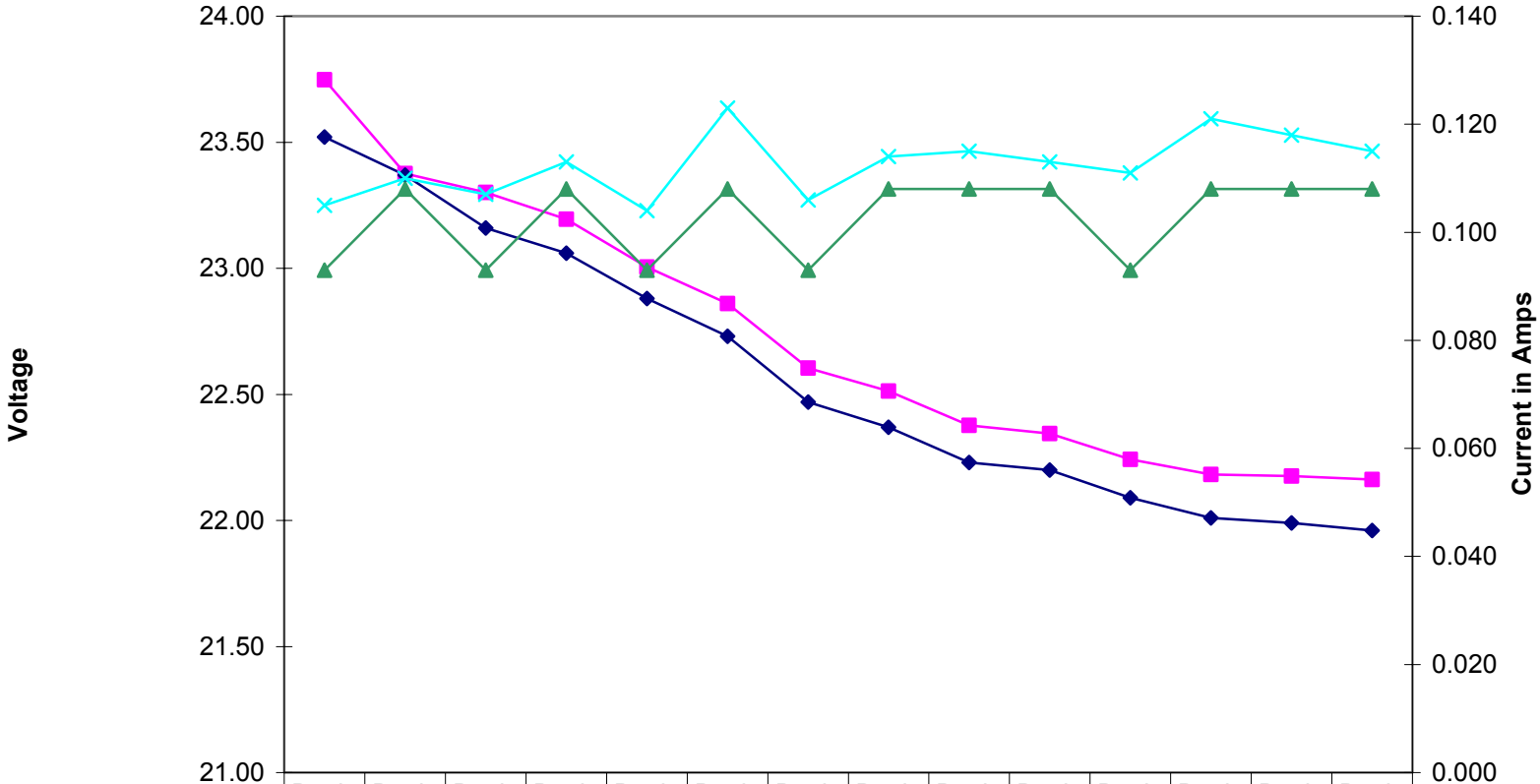
Gentex 14/2 battery, using nominal voltage



	Device 1	Device 2	Device 3	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10	Device 12	Device 13	Device 14
Calculated voltage	23.12	22.75	22.67	22.37	22.23	21.97	21.88	21.75	21.71	21.55	21.55	21.53
Actual measured voltage	23.52	23.37	23.16	22.88	22.73	22.47	22.37	22.23	22.20	22.01	21.99	21.96
Manufacturer listed current	0.093	0.108	0.093	0.093	0.108	0.093	0.108	0.108	0.108	0.108	0.108	0.108
Actual measured current	0.105	0.110	0.107	0.104	0.123	0.106	0.114	0.115	0.113	0.121	0.118	0.115

Project Name		Gentex (AFP-200 w/CBC - PL)				**POINT-POINT LIMITS MEET**			**Calculation method FAILED**			
Date												
Circuit Number		14-2 Using actual voltage				Standard Wire Resistance per 1000						
Notes		Battery power with no standby time				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			24.63	Actual = **see notes**		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.437		Wire	Ohm's	Alternate Calculations						
				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	435	3.838	1.437	435	1.919
	Listed	from	Voltage			Actual	1.575	435	4.207	1.575	435	2.103
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	23.75	0.88	3.58%	0.105	100	***23.52***	GXS			
Device 2	0.108	45	23.38	1.25	5.09%	0.110	45	***23.37***	GX-90S	Actual V drop of 2.67 / lump sum		
Device 3	0.093	10	23.30	1.33	5.40%	0.107	10	***23.16***	GXS	V drop of 4.21 = **+36% variation**:		
Device 4	0.108	15	23.20	1.43	5.83%	0.113	15	***23.06***	GX-90S	Actual V drop of 2.67 / load		
Device 5	0.093	30	23.00	1.63	6.60%	0.104	30	***22.88***	GXS	centering V drop of 2.10 = ***--27%***		
Device 6	0.108	25	22.86	1.77	7.19%	0.123	25	***22.73***	GX-90S	**variation**: using actual currents.		
Device 7	0.093	50	22.60	2.03	8.23%	0.106	50	***22.47***	GXS			
Device 8	0.108	20	22.51	2.12	8.60%	0.114	20	***22.37***	GX-90S			
Device 9	0.108	35	22.38	2.25	9.15%	0.115	35	***22.23***	GX-90S			
Device 10	0.108	10	22.34	2.29	9.28%	0.113	10	***22.20***	GX-90S			
Device 11	0.093	40	22.24	2.39	9.69%	0.111	40	***22.09***	GXS			
Device 12	0.108	30	22.18	2.45	9.94%	0.121	30	***22.01***	GX-90S			
Device 13	0.108	5	22.18	2.45	9.96%	0.118	5	***21.99***	GX-90S			
Device 14	0.108	20	22.16	2.47	10.02%	0.115	20	***21.96***	GX-90S			
END			22.16	2.47	10.02%							
END			22.16	2.47	10.02%							
END			22.16	2.47	10.02%							
END			22.16	2.47	10.02%							
END			22.16	2.47	10.02%							
END			22.16	2.47	10.02%							
Totals	1.437	435				1.575	435					
Actual voltage was 1% below calculated voltage throught test. Calculation method FAILED.												
Notes: Start voltage 24.63 at 1.63A, 8 minutes into test 24.39 volts at 1.63A, 16 minutes into test 24.35 volts at 1.62A.												

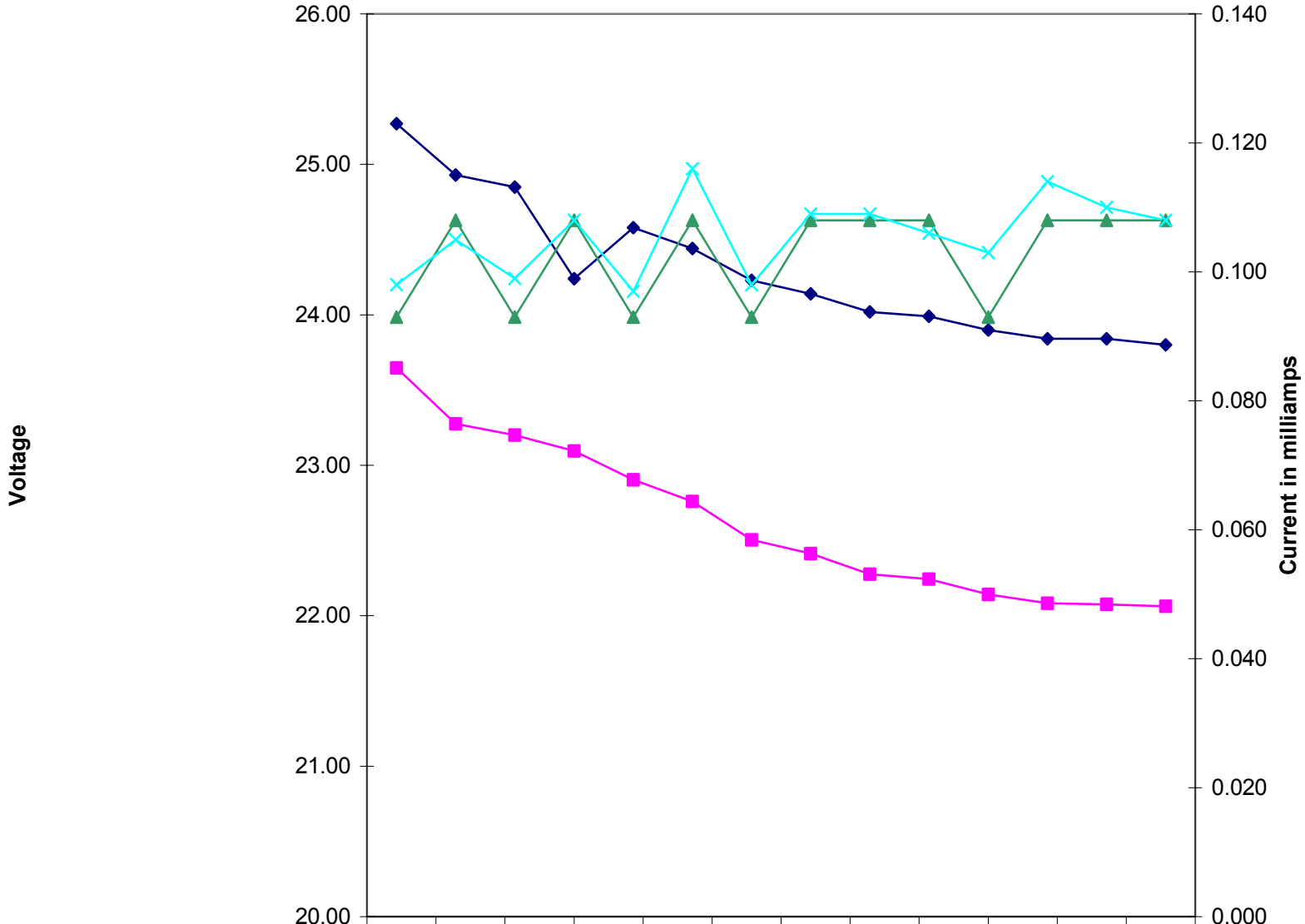
Gentex 14-2, battery, using actual voltage (1% variation) [point-point calculation method failed]



	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10	Device 11	Device 12	Device 13	Device 14
Calc. voltage	23.75	23.38	23.30	23.20	23.00	22.86	22.60	22.51	22.38	22.34	22.24	22.18	22.18	22.16
Actual voltage	23.52	23.37	23.16	23.06	22.88	22.73	22.47	22.37	22.23	22.20	22.09	22.01	21.99	21.96
Listed current	0.093	0.108	0.093	0.108	0.093	0.108	0.093	0.108	0.108	0.108	0.093	0.108	0.108	0.108
Actual current	0.105	0.110	0.107	0.113	0.104	0.123	0.106	0.114	0.115	0.113	0.111	0.121	0.118	0.115

Project Name		Gentex (AFP-200 w/CBC - PL)				POINT-POINT LIMITS MEET						
Date												
Circuit Number		14-3 (Compare to Gentex 18-3)				Standard Wire Resistance per 1000						
Notes		110 vac, solid tone, not synched.				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = 25.62		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.437		Wire	Ohm's	Alternate Calculations						
Actual total current 1.52A				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			40	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	375	3.309	1.437	375	1.654
	Listed	from		Voltage		Actual	1.480	435	3.953	1.480	435	1.976
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	23.65	0.35	1.47%	0.098	100	25.27	GXS			
Device 2	0.108	45	23.28	0.72	3.02%	0.105	45	24.93	GXS-90S			
Device 3	0.093	10	23.20	0.80	3.33%	0.099	10	24.85	GXS			
Device 4	0.108	15	23.09	0.91	3.77%	0.108	15	24.24	GX-90S			
Device 5	0.093	30	22.90	1.10	4.57%	0.097	30	24.58	GXS			
Device 6	0.108	25	22.76	1.24	5.17%	0.116	25	24.44	GX-90S			
Device 7	0.093	50	22.50	1.50	6.24%	0.098	50	24.23	GXS			
Device 8	0.108	20	22.41	1.59	6.62%	0.109	20	24.14	GX-90S			
Device 9	0.108	35	22.28	1.72	7.18%	0.109	35	24.02	GX-90S			
Device 10	0.108	10	22.24	1.76	7.32%	0.106	10	23.99	GX-90S			
Device 11	0.093	40	22.14	1.86	7.74%	0.103	40	23.90	GXS			
Device 12	0.108	30	22.08	1.92	7.99%	0.114	30	23.84	GX-90S			
Device 13	0.108	5	22.08	1.92	8.02%	0.110	5	23.84	GX-90S			
Device 14	0.108	20	22.06	1.94	8.07%	0.108	20	23.80	GX-90S			
END			22.06	1.94	8.07%							
END			22.06	1.94	8.07%							
END			22.06	1.94	8.07%							
END			22.06	1.94	8.07%							
END			22.06	1.94	8.07%							
END			22.06	1.94	8.07%							
Totals	1.437	375				1.480	435					

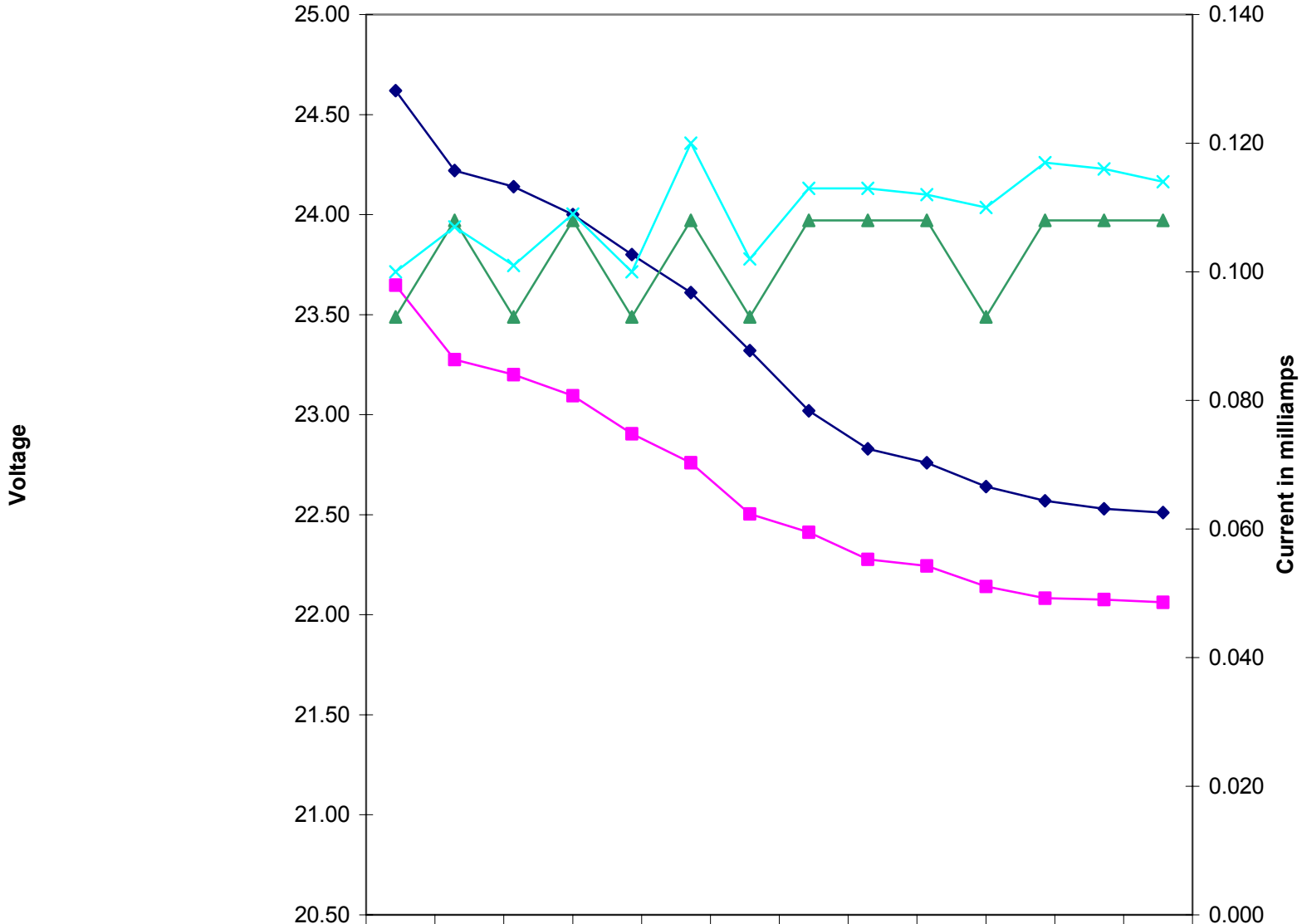
Gentex 14/3



	Device 1	Device 2	Device 3	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10	Device 12	Device 13	Device 14
Calculated voltage	23.65	23.28	23.20	22.90	22.76	22.50	22.41	22.28	22.24	22.08	22.08	22.06
Actual measured voltage	25.27	24.93	24.85	24.58	24.44	24.23	24.14	24.02	23.99	23.84	23.84	23.80
Manufacturer listed current	0.093	0.108	0.093	0.093	0.108	0.093	0.108	0.108	0.108	0.108	0.108	0.108
Actual measured current	0.098	0.105	0.099	0.097	0.116	0.098	0.109	0.109	0.106	0.114	0.110	0.108

Project Name		Gentex (AFP-200 w/CBC - PL)				POINT-POINT LIMITS MEET						
Date												
Circuit Number		14-3 (Compare to Gentex 18-3)				Standard Wire Resistance per 1000						
Notes		Battery power with no standby time				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = see notes		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.437		Wire	Ohm's	Alternate Calculations						
				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			40	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	375	3.309	1.437	375	1.654
	Listed	from		Voltage		Actual	1.534	435	4.097	1.534	435	2.049
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	23.65	0.35	1.47%	0.100	100	24.62	GXS			
Device 2	0.108	45	23.28	0.72	3.02%	0.107	45	24.22	GXS-90S			
Device 3	0.093	10	23.20	0.80	3.33%	0.101	10	24.14	GXS			
Device 4	0.108	15	23.09	0.91	3.77%	0.109	15	24.00	GX-90S			
Device 5	0.093	30	22.90	1.10	4.57%	0.100	30	23.80	GXS			
Device 6	0.108	25	22.76	1.24	5.17%	0.120	25	23.61	GX-90S			
Device 7	0.093	50	22.50	1.50	6.24%	0.102	50	23.32	GXS			
Device 8	0.108	20	22.41	1.59	6.62%	0.113	20	23.02	GX-90S			
Device 9	0.108	35	22.28	1.72	7.18%	0.113	35	22.83	GX-90S			
Device 10	0.108	10	22.24	1.76	7.32%	0.112	10	22.76	GX-90S			
Device 11	0.093	40	22.14	1.86	7.74%	0.110	40	22.64	GXS			
Device 12	0.108	30	22.08	1.92	7.99%	0.117	30	22.57	GX-90S			
Device 13	0.108	5	22.08	1.92	8.02%	0.116	5	22.53	GX-90S			
Device 14	0.108	20	22.06	1.94	8.07%	0.114	20	22.51	GX-90S			
END			22.06	1.94	8.07%							
END			22.06	1.94	8.07%							
END			22.06	1.94	8.07%							
END			22.06	1.94	8.07%							
END			22.06	1.94	8.07%							
END			22.06	1.94	8.07%							
Totals	1.437	375				1.534	435					
Notes: Start voltage 25.45 at 1.53A, 8 minutes into test 24.67 volts at 1.56A, end of test 24.35volts at 1.59A.												

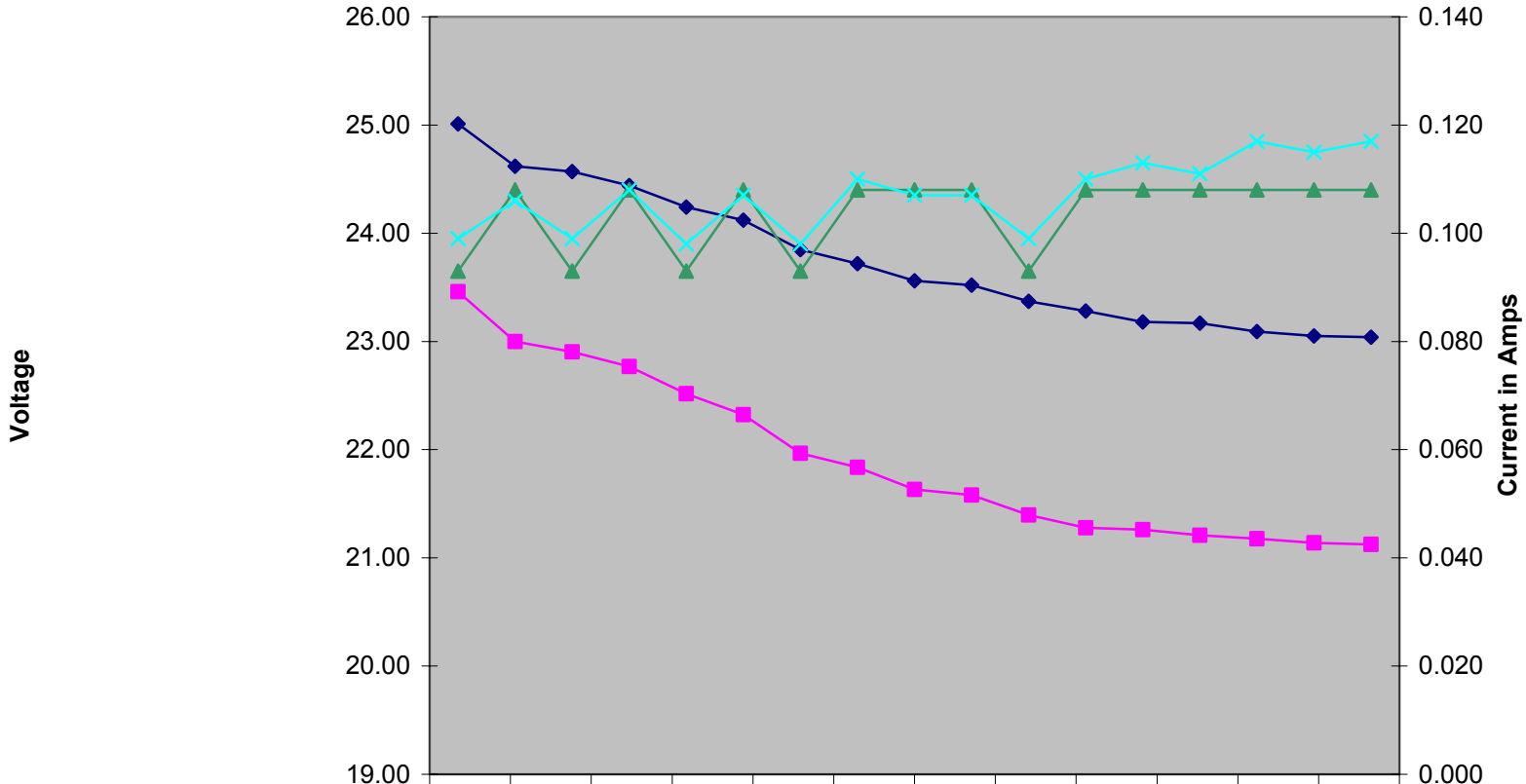
Gentex 14/3a battery



	Device 1	Device 2	Device 3	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10	Device 12	Device 13	Device 14
Calculated voltage	23.65	23.28	23.20	22.90	22.76	22.50	22.41	22.28	22.24	22.08	22.08	22.06
Actual measured voltage	24.62	24.22	24.14	23.80	23.61	23.32	23.02	22.83	22.76	22.57	22.53	22.51
Manufacturer listed current	0.093	0.108	0.093	0.093	0.108	0.093	0.108	0.108	0.108	0.108	0.108	0.108
Actual measured current	0.100	0.107	0.101	0.100	0.120	0.102	0.113	0.113	0.112	0.117	0.116	0.114

Project Name		Gentex				POINT-POINT LIMITS MEET						
Date												
Circuit Number		14-4				Standard Wire Resistance per 1000						
Notes		110 Vac, solid tone, strobes not synched				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = 25.53		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.761		Wire	Ohm's	Alternate Calculations						
Actual measured current = 1.80				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			50	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.761	450	4.866	1.761	450	2.433
	Listed	from	Voltage			Actual	1.821	500	5.590	1.821	500	2.795
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	23.46	0.54	2.25%	0.099	100	25.01	GXS			
Device 2	0.108	45	23.00	1.00	4.17%	0.106	45	24.62	GXS-90S			
Device 3	0.093	10	22.90	1.10	4.57%	0.099	10	24.57	GXS			
Device 4	0.108	15	22.77	1.23	5.13%	0.108	15	24.44	GX-90S			
Device 5	0.093	30	22.52	1.48	6.18%	0.098	30	24.24	GXS			
Device 6	0.108	25	22.32	1.68	6.99%	0.107	25	24.12	GX-90S			
Device 7	0.093	50	21.97	2.03	8.47%	0.098	50	23.85	GXS			
Device 8	0.108	20	21.84	2.16	9.01%	0.110	20	23.72	GX-90S			
Device 9	0.108	35	21.63	2.37	9.87%	0.107	35	23.56	GX-90S			
Device 10	0.108	10	21.58	2.42	10.09%	0.107	10	23.52	GX-90S			
Device 11	0.093	40	21.40	2.60	10.85%	0.099	40	23.37	GXS			
Device 12	0.108	30	21.28	2.72	11.34%	0.110	30	23.28	GX-90S			
Device 13	0.108	5	21.26	2.74	11.41%	0.113	5	23.18	GX-90S			
Device 14	0.108	20	21.21	2.79	11.63%	0.111	20	23.17	GX-90S			
Device 15	0.108	15	21.18	2.82	11.76%	0.117	15	23.09	GX-90S			
Device 16	0.108	30	21.14	2.86	11.92%	0.115	30	23.05	GX-90S			
Device 17	0.108	20	21.13	2.87	11.98%	0.117	20	23.04	GX-90S			
END			21.13	2.87	11.98%							
END			21.13	2.87	11.98%							
END			21.13	2.87	11.98%							
Totals	1.761	450				1.821	500					

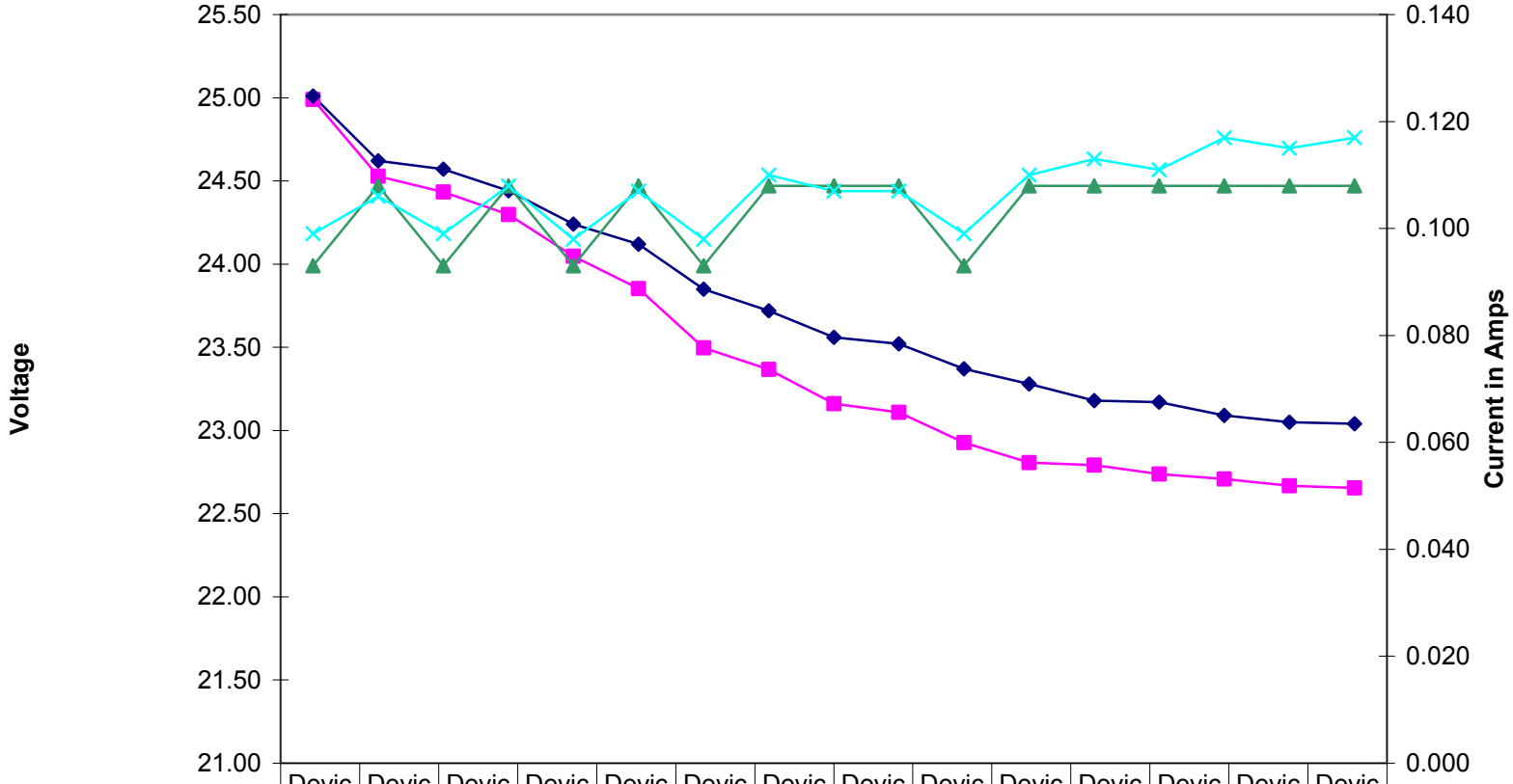
Gentex 14-4 using nominal voltage



	Device 1	Device 2	Device 4	Device 5	Device 7	Device 8	Device 10	Device 11	Device 12	Device 14	Device 15	Device 17
Calculated voltage	23.46	23.00	22.77	22.52	21.97	21.84	21.58	21.40	21.28	21.21	21.18	21.13
Actual measured voltage	25.01	24.62	24.44	24.24	23.85	23.72	23.52	23.37	23.28	23.17	23.09	23.04
Manufacturer listed current	0.093	0.108	0.108	0.093	0.093	0.108	0.108	0.093	0.108	0.108	0.108	0.108
Actual measured current	0.099	0.106	0.108	0.098	0.098	0.110	0.107	0.099	0.110	0.111	0.117	0.117

Project Name		Gentex				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14-4 using actual voltage				Standard Wire Resistance per 1000						
Notes		110 Vac, solid tone, strobes not synched				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			25.53			When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.761		Wire	Ohm's	Alternate Calculations						
Actual measured current = 1.80				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			50	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.761	450	4.866	1.761	450	2.433
	Listed	from	Voltage			Actual	1.821	500	5.590	1.821	500	2.795
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	24.99	0.54	2.12%	0.099	100	25.01	GXS			
Device 2	0.108	45	24.53	1.00	3.92%	0.106	45	24.62	GXS-90S	Actual V drop of 2.49 / lump sum		
Device 3	0.093	10	24.43	1.10	4.30%	0.099	10	24.57	GXS	V drop of 5.59 = **+55% variation**:		
Device 4	0.108	15	24.30	1.23	4.83%	0.108	15	24.44	GX-90S	Actual V drop of 2.49 / load		
Device 5	0.093	30	24.05	1.48	5.81%	0.098	30	24.24	GXS	centering V drop of 2.79 = **+11%**		
Device 6	0.108	25	23.85	1.68	6.57%	0.107	25	24.12	GX-90S	**variation**: using actual currents.		
Device 7	0.093	50	23.50	2.03	7.96%	0.098	50	23.85	GXS			
Device 8	0.108	20	23.37	2.16	8.47%	0.110	20	23.72	GX-90S			
Device 9	0.108	35	23.16	2.37	9.28%	0.107	35	23.56	GX-90S			
Device 10	0.108	10	23.11	2.42	9.48%	0.107	10	23.52	GX-90S			
Device 11	0.093	40	22.93	2.60	10.20%	0.099	40	23.37	GXS			
Device 12	0.108	30	22.81	2.72	10.66%	0.110	30	23.28	GX-90S			
Device 13	0.108	5	22.79	2.74	10.73%	0.113	5	23.18	GX-90S			
Device 14	0.108	20	22.74	2.79	10.94%	0.111	20	23.17	GX-90S			
Device 15	0.108	15	22.71	2.82	11.05%	0.117	15	23.09	GX-90S			
Device 16	0.108	30	22.67	2.86	11.21%	0.115	30	23.05	GX-90S			
Device 17	0.108	20	22.66	2.87	11.26%	0.117	20	23.04	GX-90S			
END			22.66	2.87	11.26%							
END			22.66	2.87	11.26%							
END			22.66	2.87	11.26%							
Totals	1.761	450				1.821	500					
Actual voltage has up to a 2% variation.												

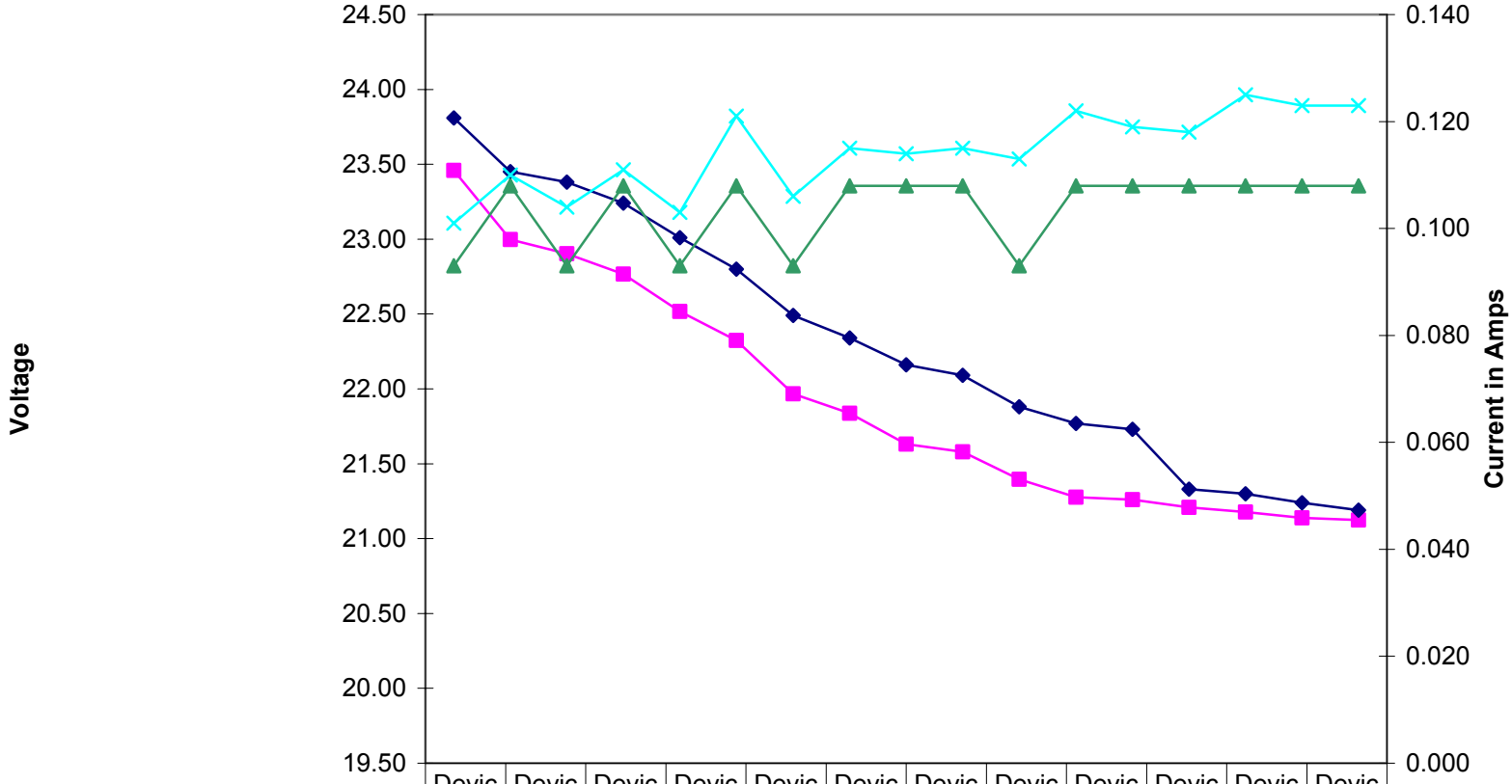
Gentex 14-4 using actual voltage (2% variation)



	Device 1	Device 2	Device 3	Device 5	Device 6	Device 7	Device 8	Device 10	Device 11	Device 12	Device 13	Device 14	Device 16	Device 17
Calc. voltage	24.99	24.53	24.43	24.05	23.85	23.50	23.37	23.11	22.93	22.81	22.79	22.74	22.67	22.66
Actual voltage	25.01	24.62	24.57	24.24	24.12	23.85	23.72	23.52	23.37	23.28	23.18	23.17	23.05	23.04
Listed current	0.093	0.108	0.093	0.093	0.108	0.093	0.108	0.108	0.093	0.108	0.108	0.108	0.108	0.108
Actual current	0.099	0.106	0.099	0.098	0.107	0.098	0.110	0.107	0.099	0.110	0.113	0.111	0.115	0.117

Project Name		Gentex				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14-5 (compare to 14-4)				Standard Wire Resistance per 1000						
Notes		Battery power, with no standby time				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = **see notes**		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.761		Wire	Ohm's	Alternate Calculations						
				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			50	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.761	450	4.866	1.761	450	2.433
	Listed	from	Voltage			Actual	1.943	500	5.965	1.943	500	2.983
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	23.46	0.54	2.25%	0.101	100	23.81	GXS			
Device 2	0.108	45	23.00	1.00	4.17%	0.110	45	23.45	GXS-90S			
Device 3	0.093	10	22.90	1.10	4.57%	0.104	10	23.38	GXS			
Device 4	0.108	15	22.77	1.23	5.13%	0.111	15	23.24	GX-90S			
Device 5	0.093	30	22.52	1.48	6.18%	0.103	30	23.01	GXS			
Device 6	0.108	25	22.32	1.68	6.99%	0.121	25	22.80	GX-90S			
Device 7	0.093	50	21.97	2.03	8.47%	0.106	50	22.49	GXS			
Device 8	0.108	20	21.84	2.16	9.01%	0.115	20	22.34	GX-90S			
Device 9	0.108	35	21.63	2.37	9.87%	0.114	35	22.16	GX-90S			
Device 10	0.108	10	21.58	2.42	10.09%	0.115	10	22.09	GX-90S			
Device 11	0.093	40	21.40	2.60	10.85%	0.113	40	21.88	GXS			
Device 12	0.108	30	21.28	2.72	11.34%	0.122	30	21.77	GX-90S			
Device 13	0.108	5	21.26	2.74	11.41%	0.119	5	21.73	GX-90S			
Device 14	0.108	20	21.21	2.79	11.63%	0.118	20	21.33	GX-90S			
Device 15	0.108	15	21.18	2.82	11.76%	0.125	15	21.30	GX-90S			
Device 16	0.108	30	21.14	2.86	11.92%	0.123	30	21.24	GX-90S			
Device 17	0.108	20	21.13	2.87	11.98%	0.123	20	21.19	GX-90S			
END			21.13	2.87	11.98%							
END			21.13	2.87	11.98%							
END			21.13	2.87	11.98%							
Totals	1.761	450				1.943	500					
Notes: Start voltage 24.22 at 1.89A, Mid (13 min) 24.17 volts at 1.803A, end (26 min) 24.10 volts at 1.91A.												

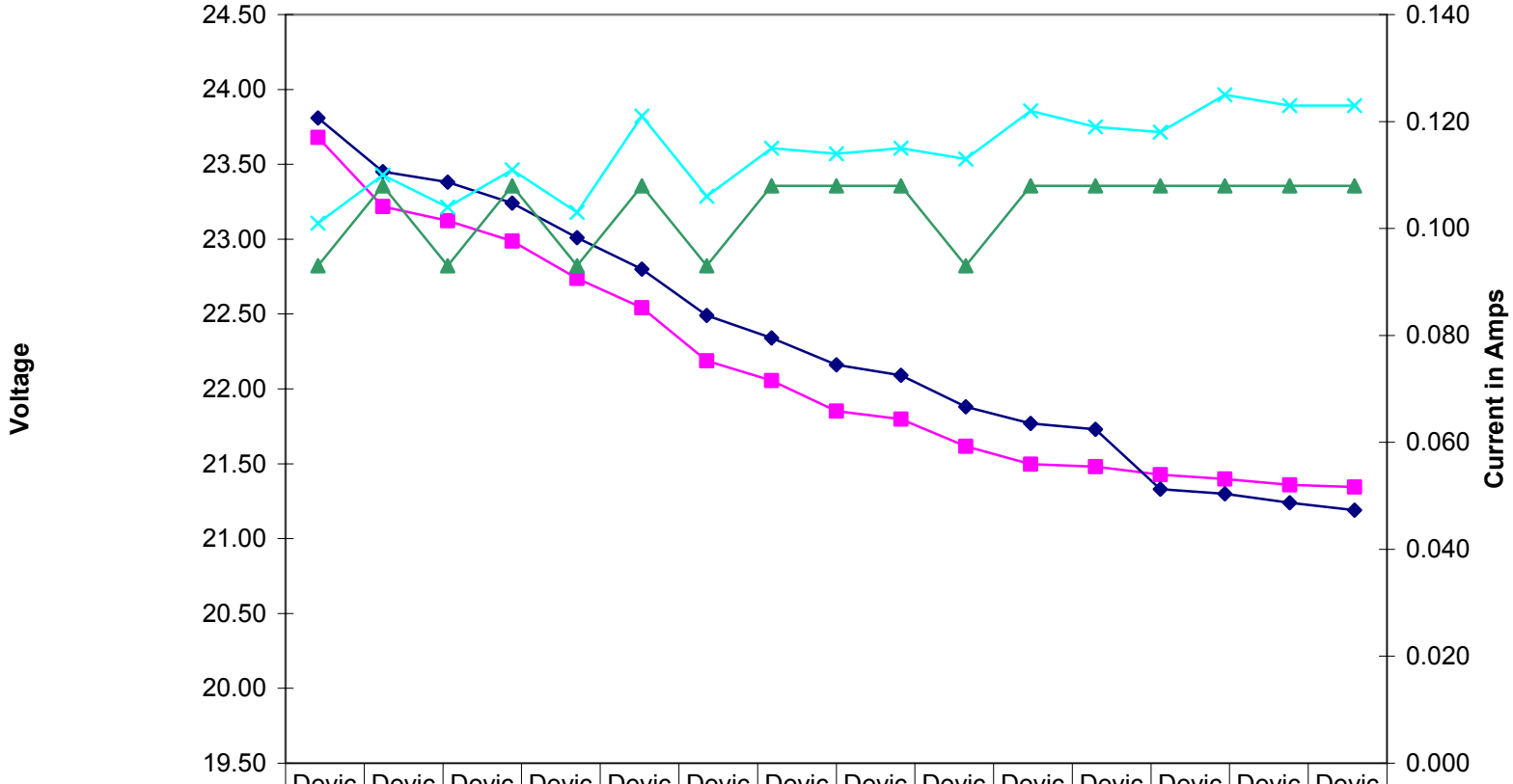
Gentex 14-5 battery, using nominal voltage



	Device 1	Device 2	Device 4	Device 5	Device 7	Device 8	Device 10	Device 11	Device 12	Device 14	Device 15	Device 17
Calculated voltage	23.46	23.00	22.77	22.52	21.97	21.84	21.58	21.40	21.28	21.21	21.18	21.13
Actual measured voltage	23.81	23.45	23.24	23.01	22.49	22.34	22.09	21.88	21.77	21.33	21.30	21.19
Manufacturer listed current	0.093	0.108	0.108	0.093	0.093	0.108	0.108	0.093	0.108	0.108	0.108	0.108
Actual measured current	0.101	0.110	0.111	0.103	0.106	0.115	0.115	0.113	0.122	0.118	0.125	0.123

Project Name		Gentex				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14-5 (compare to 14-4) Actual voltage				Standard Wire Resistance per 1000						
Notes		Battery power, with no standby time				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			24.22	Actual = **see notes**		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.761		Wire	Ohm's	Alternate Calculations						
				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			50	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.761	450	4.866	1.761	450	2.433
	Listed	from	Voltage			Actual	1.943	500	5.965	1.943	500	2.983
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	23.68	0.54	2.23%	0.101	100	23.81	GXS			
Device 2	0.108	45	23.22	1.00	4.13%	0.110	45	23.45	GXS-90S	Actual V drop of 3.03 / lump sum		
Device 3	0.093	10	23.12	1.10	4.53%	0.104	10	23.38	GXS	V drop of 5.96 = **+49% variation**:		
Device 4	0.108	15	22.99	1.23	5.09%	0.111	15	23.24	GX-90S	Actual V drop of 3.03 / load		
Device 5	0.093	30	22.74	1.48	6.12%	0.103	30	23.01	GXS	centering V drop of 2.98 = **+2%**		
Device 6	0.108	25	22.54	1.68	6.92%	0.121	25	22.80	GX-90S	**variation**: using actual currents.		
Device 7	0.093	50	22.19	2.03	8.39%	0.106	50	22.49	GXS			
Device 8	0.108	20	22.06	2.16	8.93%	0.115	20	22.34	GX-90S			
Device 9	0.108	35	21.85	2.37	9.78%	0.114	35	22.16	GX-90S			
Device 10	0.108	10	21.80	2.42	10.00%	0.115	10	22.09	GX-90S			
Device 11	0.093	40	21.62	2.60	10.75%	0.113	40	21.88	GXS			
Device 12	0.108	30	21.50	2.72	11.24%	0.122	30	21.77	GX-90S			
Device 13	0.108	5	21.48	2.74	11.31%	0.119	5	21.73	GX-90S			
Device 14	0.108	20	21.43	2.79	11.53%	0.118	20	21.33	GX-90S			
Device 15	0.108	15	21.40	2.82	11.65%	0.125	15	21.30	GX-90S			
Device 16	0.108	30	21.36	2.86	11.82%	0.123	30	21.24	GX-90S			
Device 17	0.108	20	21.35	2.87	11.87%	0.123	20	21.19	GX-90S			
END			21.35	2.87	11.87%							
END			21.35	2.87	11.87%							
END			21.35	2.87	11.87%							
Totals	1.761	450				1.943	500					
Actual voltage maintained a 1% variation until device 14 about 20 minutes into test. Since the change occurred so late into test, results are considered as passed.												
Notes: Start voltage 24.22 at 1.89A, Mid (13 min) 24.17 volts at 1.803A, end (26 min) 24.10 volts at 1.91A.												

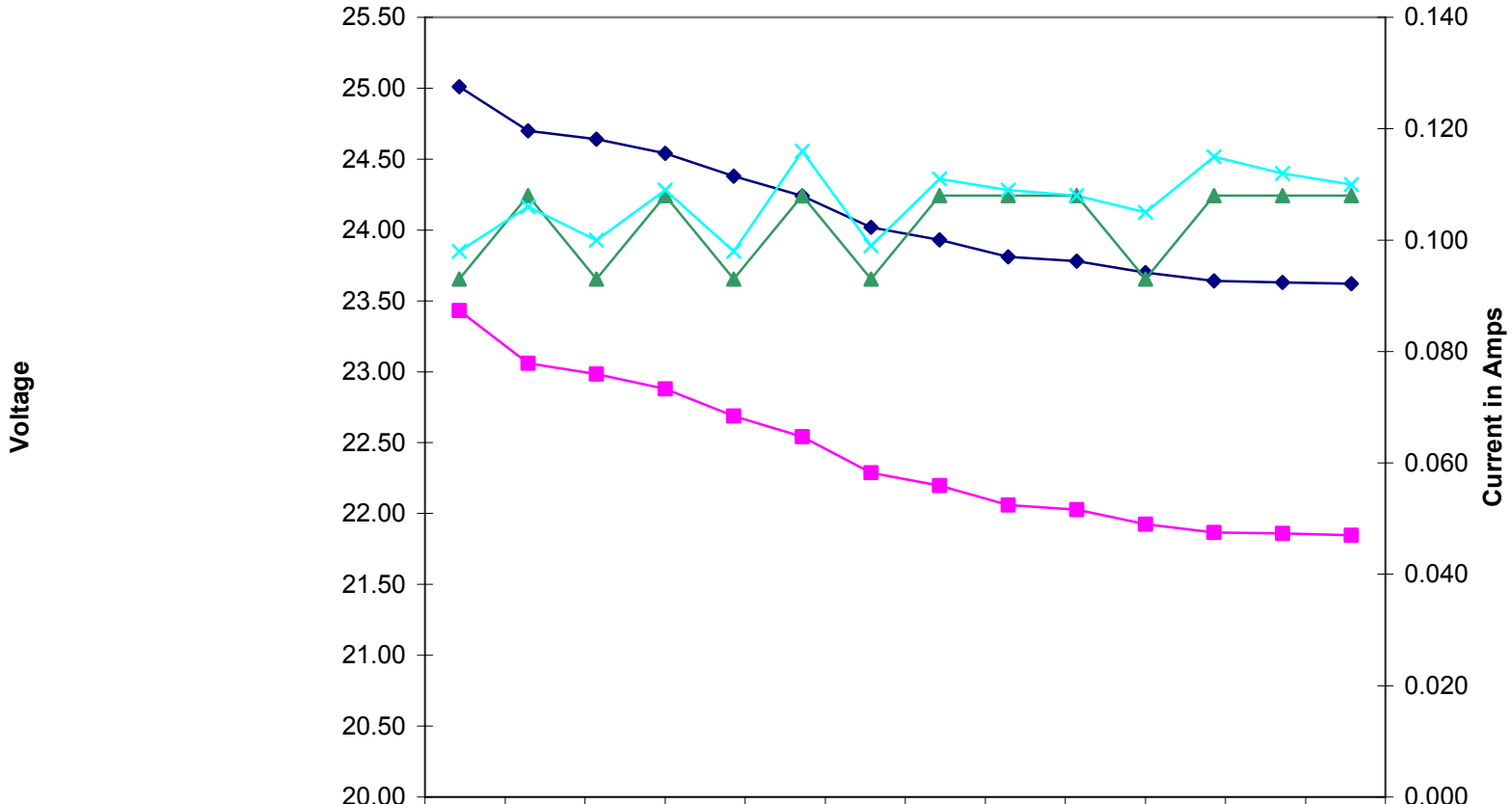
Gentex 14-5 battery using actual voltage (1% variation)



	Device 1	Device 2	Device 3	Device 5	Device 6	Device 7	Device 8	Device 10	Device 11	Device 12	Device 13	Device 14	Device 16	Device 17
Calc. voltage	23.68	23.22	23.12	22.74	22.54	22.19	22.06	21.80	21.62	21.50	21.48	21.43	21.36	21.35
Actual voltage	23.81	23.45	23.38	23.01	22.80	22.49	22.34	22.09	21.88	21.77	21.73	21.33	21.24	21.19
Listed current	0.093	0.108	0.093	0.093	0.108	0.093	0.108	0.108	0.093	0.108	0.108	0.108	0.108	0.108
Actual current	0.101	0.110	0.104	0.103	0.121	0.106	0.115	0.115	0.113	0.122	0.119	0.118	0.123	0.123

Project Name		Gentex (AFP-200 w/CBC - PL)				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14/12-1 (compare to Gentex 14-1)				Standard Wire Resistance per 1000						
Notes		110 vac, solid tone, strobes not synched				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = 25.46		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current amp		1.437		Wire	Ohm's	Alternate Calculations						
Actual total current = 1.55				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	12	1.98		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	435	3.838	1.437	435	1.919
	Listed	from	Voltage			Actual	1.496	435	3.996	1.496	435	1.998
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	23.43	0.57	2.37%	0.098	100	25.01	GXS			
Device 2	0.108	45	23.06	0.94	3.92%	0.106	45	24.70	GX-90S			
Device 3	0.093	10	22.98	1.02	4.23%	0.100	10	24.64	GXS			
Device 4	0.108	15	22.88	1.12	4.67%	0.109	15	24.54	GX-90S			
Device 5	0.093	30	22.69	1.31	5.47%	0.098	30	24.38	GXS			
Device 6	0.108	25	22.54	1.46	6.07%	0.116	25	24.24	GX-90S			
Device 7	0.093	50	22.29	1.71	7.14%	0.099	50	24.02	GXS			
Device 8	0.108	20	22.20	1.80	7.52%	0.111	20	23.93	GX-90S			
Device 9	0.108	35	22.06	1.94	8.08%	0.109	35	23.81	GX-90S			
Device 10	0.108	10	22.03	1.97	8.22%	0.108	10	23.78	GX-90S			
Device 11	0.093	40	21.93	2.07	8.64%	0.105	40	23.70	GXS			
Device 12	0.108	30	21.87	2.13	8.89%	0.115	30	23.64	GX-90S			
Device 13	0.108	5	21.86	2.14	8.92%	0.112	5	23.63	GX-90S			
Device 14	0.108	20	21.85	2.15	8.98%	0.110	20	23.62	GX-90S			
END			21.85	2.15	8.98%							
END			21.85	2.15	8.98%							
END			21.85	2.15	8.98%							
END			21.85	2.15	8.98%							
END			21.85	2.15	8.98%							
END			21.85	2.15	8.98%							
Totals	1.437	435				1.496	435					

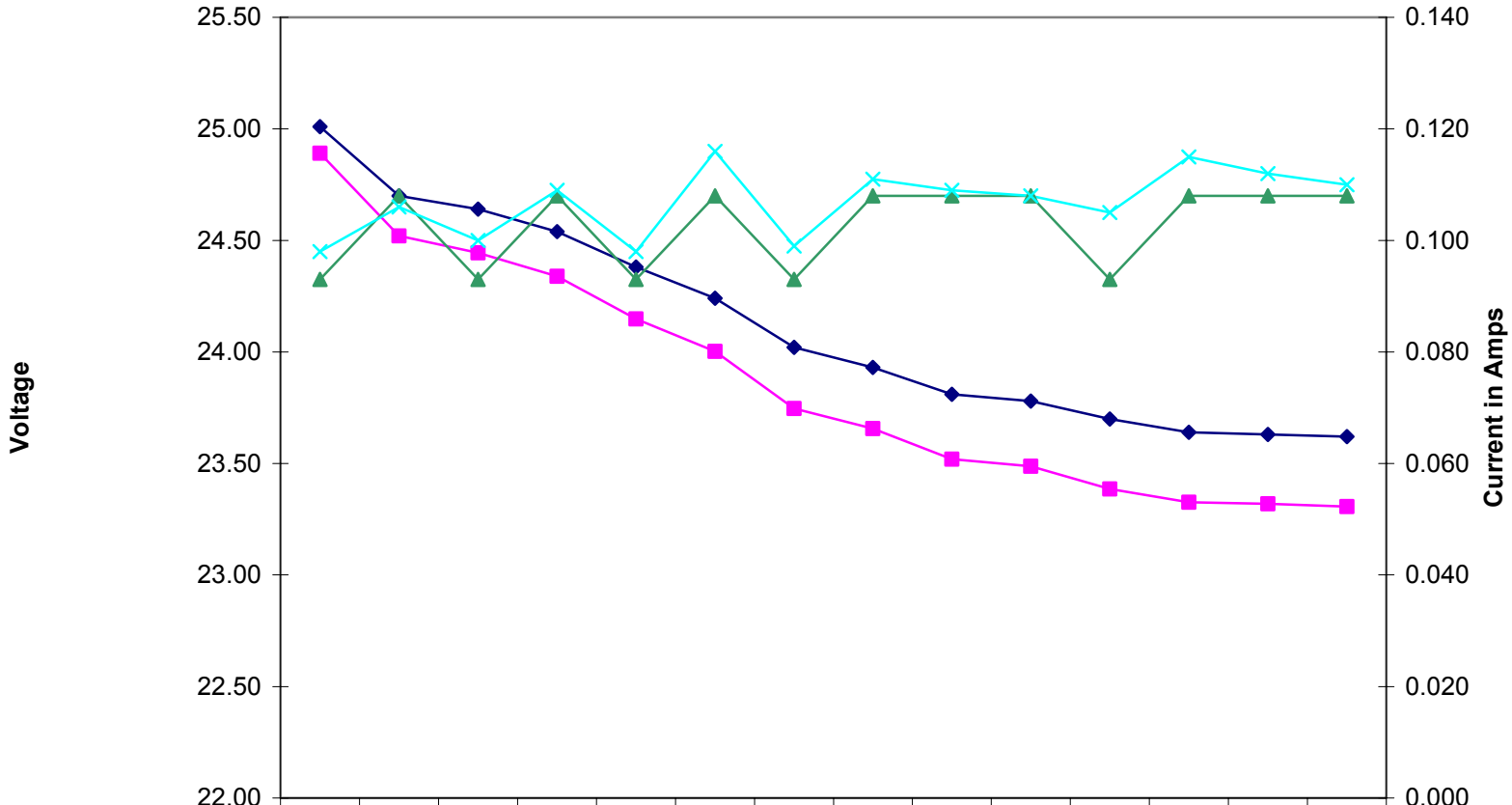
Gentex 14/12-1 using nominal voltage



	Device 1	Device 2	Device 3	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10	Device 12	Device 13	Device 14
Calculated voltage	23.43	23.06	22.98	22.69	22.54	22.29	22.20	22.06	22.03	21.87	21.86	21.85
Actual measured voltage	25.01	24.70	24.64	24.38	24.24	24.02	23.93	23.81	23.78	23.64	23.63	23.62
Manufacturer listed current	0.093	0.108	0.093	0.093	0.108	0.093	0.108	0.108	0.108	0.108	0.108	0.108
Actual measured current	0.098	0.106	0.100	0.098	0.116	0.099	0.111	0.109	0.108	0.115	0.112	0.110

Project Name		Gentex (AFP-200 w/CBC - PL)				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14/12-1 (compare to Gentex 14-1) Actual volt.				Standard Wire Resistance per 1000						
Notes		110 vac, solid tone, strobes not synched				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			25.46			When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current amp		1.437		Wire	Ohm's	Alternate Calculations						
Actual total current = 1.55				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	12	1.98		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.437	435	3.838	1.437	435	1.919
	Listed	from	Voltage			Actual	1.496	435	3.996	1.496	435	1.998
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	24.89	0.57	2.24%	0.098	100	25.01	GXS	Actual V drop of 1.84 / lump sum		
Device 2	0.108	45	24.52	0.94	3.69%	0.106	45	24.70	GX-90S	V drop of 4.00 = **+54% variation**		
Device 3	0.093	10	24.44	1.02	3.99%	0.100	10	24.64	GXS	: Actual V drop 1.84 / load		
Device 4	0.108	15	24.34	1.12	4.41%	0.109	15	24.54	GX-90S	centering V drop 1.92 = **+8%**		
Device 5	0.093	30	24.15	1.31	5.15%	0.098	30	24.38	GXS	**variation**: using actual currents		
Device 6	0.108	25	24.00	1.46	5.72%	0.116	25	24.24	GX-90S			
Device 7	0.093	50	23.75	1.71	6.73%	0.099	50	24.02	GXS			
Device 8	0.108	20	23.66	1.80	7.08%	0.111	20	23.93	GX-90S			
Device 9	0.108	35	23.52	1.94	7.62%	0.109	35	23.81	GX-90S			
Device 10	0.108	10	23.49	1.97	7.75%	0.108	10	23.78	GX-90S			
Device 11	0.093	40	23.39	2.07	8.15%	0.105	40	23.70	GXS			
Device 12	0.108	30	23.33	2.13	8.38%	0.115	30	23.64	GX-90S			
Device 13	0.108	5	23.32	2.14	8.41%	0.112	5	23.63	GX-90S			
Device 14	0.108	20	23.31	2.15	8.46%	0.110	20	23.62	GX-90S			
END			23.31	2.15	8.46%							
END			23.31	2.15	8.46%							
END			23.31	2.15	8.46%							
END			23.31	2.15	8.46%							
END			23.31	2.15	8.46%							
END			23.31	2.15	8.46%							
Totals	1.437	435				1.496	435					
Actual voltage was 1% above calculated.												

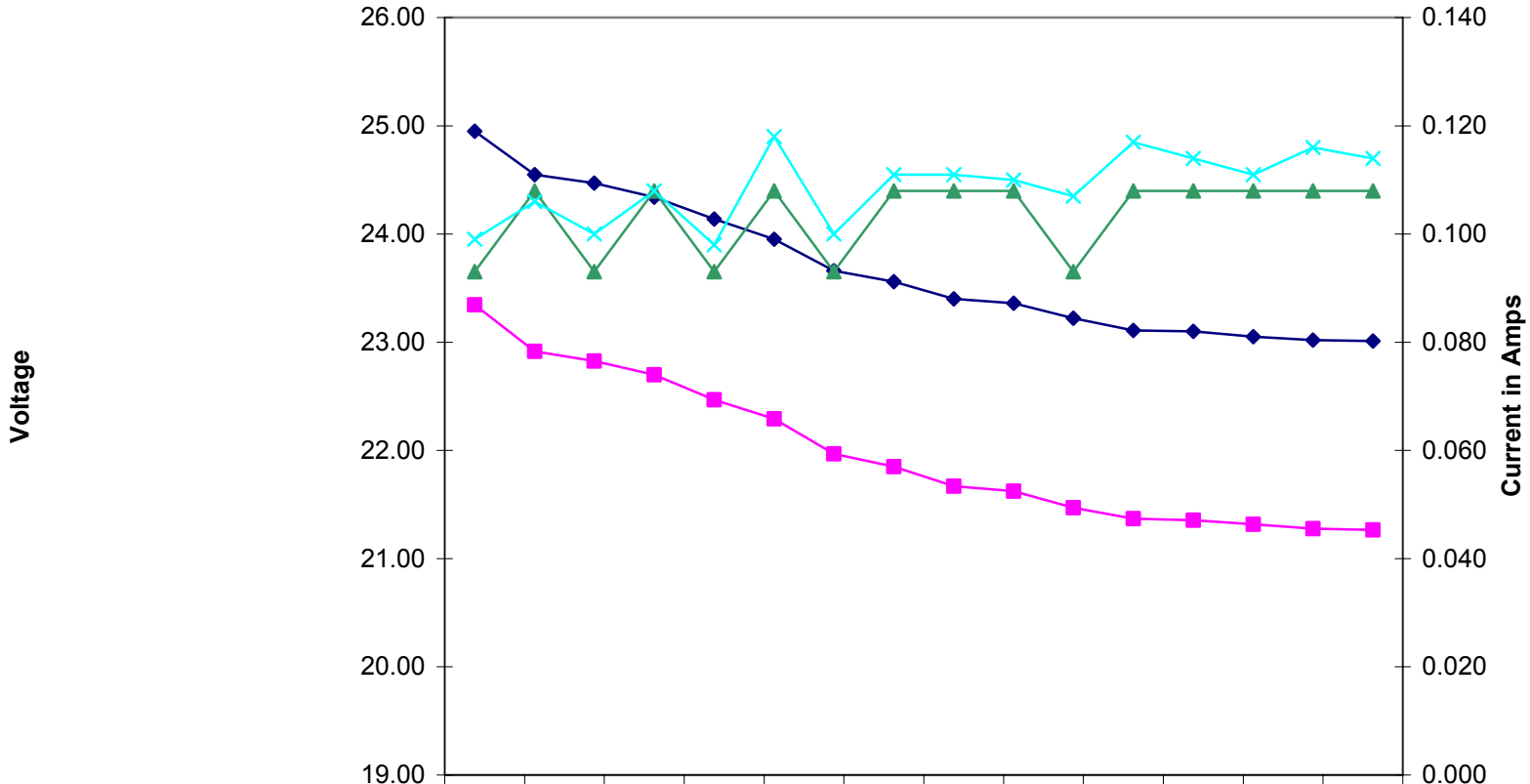
Gentex 14/12-1 using actual voltage (1% variation)



	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10	Device 11	Device 12	Device 13	Device 14
Calc. voltage	24.89	24.52	24.44	24.34	24.15	24.00	23.75	23.66	23.52	23.49	23.39	23.33	23.32	23.31
Actual voltage	25.01	24.70	24.64	24.54	24.38	24.24	24.02	23.93	23.81	23.78	23.70	23.64	23.63	23.62
Listed current	0.093	0.108	0.093	0.108	0.093	0.108	0.093	0.108	0.108	0.108	0.093	0.108	0.108	0.108
Actual current	0.098	0.106	0.100	0.109	0.098	0.116	0.099	0.111	0.109	0.108	0.105	0.115	0.112	0.110

Project Name		Gentex (AFP-200 w/CBC - PL)				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14/12-2 (added devices to 14/12-1)				Standard Wire Resistance per 1000						
Notes		110 vac, solid tone, strobes not synched				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = 25.58		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current amp		1.653		Wire	Ohm's	Alternate Calculations						
Actual total current = 1.802				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	12	1.98		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.653	480	4.872	1.653	480	2.436
	Listed	from		Voltage		Actual	1.740	480	5.128	1.740	480	2.564
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	23.35	0.65	2.73%	0.099	100	24.95	GXS			
Device 2	0.108	45	22.91	1.09	4.52%	0.106	45	24.55	GX-90S			
Device 3	0.093	10	22.83	1.17	4.89%	0.100	10	24.47	GXS			
Device 4	0.108	15	22.70	1.30	5.42%	0.108	15	24.34	GX-90S			
Device 5	0.093	30	22.47	1.53	6.38%	0.098	30	24.14	GXS			
Device 6	0.108	25	22.29	1.71	7.12%	0.118	25	23.95	GX-90S			
Device 7	0.093	50	21.97	2.03	8.46%	0.100	50	23.66	GXS			
Device 8	0.108	20	21.85	2.15	8.95%	0.111	20	23.56	GX-90S			
Device 9	0.108	35	21.67	2.33	9.71%	0.111	35	23.40	GX-90S			
Device 10	0.108	10	21.62	2.38	9.90%	0.110	10	23.36	GX-90S			
Device 11	0.093	40	21.47	2.53	10.55%	0.107	40	23.22	GXS			
Device 12	0.108	30	21.37	2.63	10.96%	0.117	30	23.11	GX-90S			
Device 13	0.108	5	21.36	2.64	11.02%	0.114	5	23.10	GX-90S			
Device 14	0.108	20	21.32	2.68	11.18%	0.111	20	23.05	GX-90S			
Device 15	0.108	30	21.28	2.72	11.35%	0.116	30	23.02	GX-90S			
Device 16	0.108	15	21.27	2.73	11.39%	0.114	15	23.01	GX-90S			
END			21.27	2.73	11.39%							
END			21.27	2.73	11.39%							
END			21.27	2.73	11.39%							
END			21.27	2.73	11.39%							
Totals	1.653	480				1.740	480					

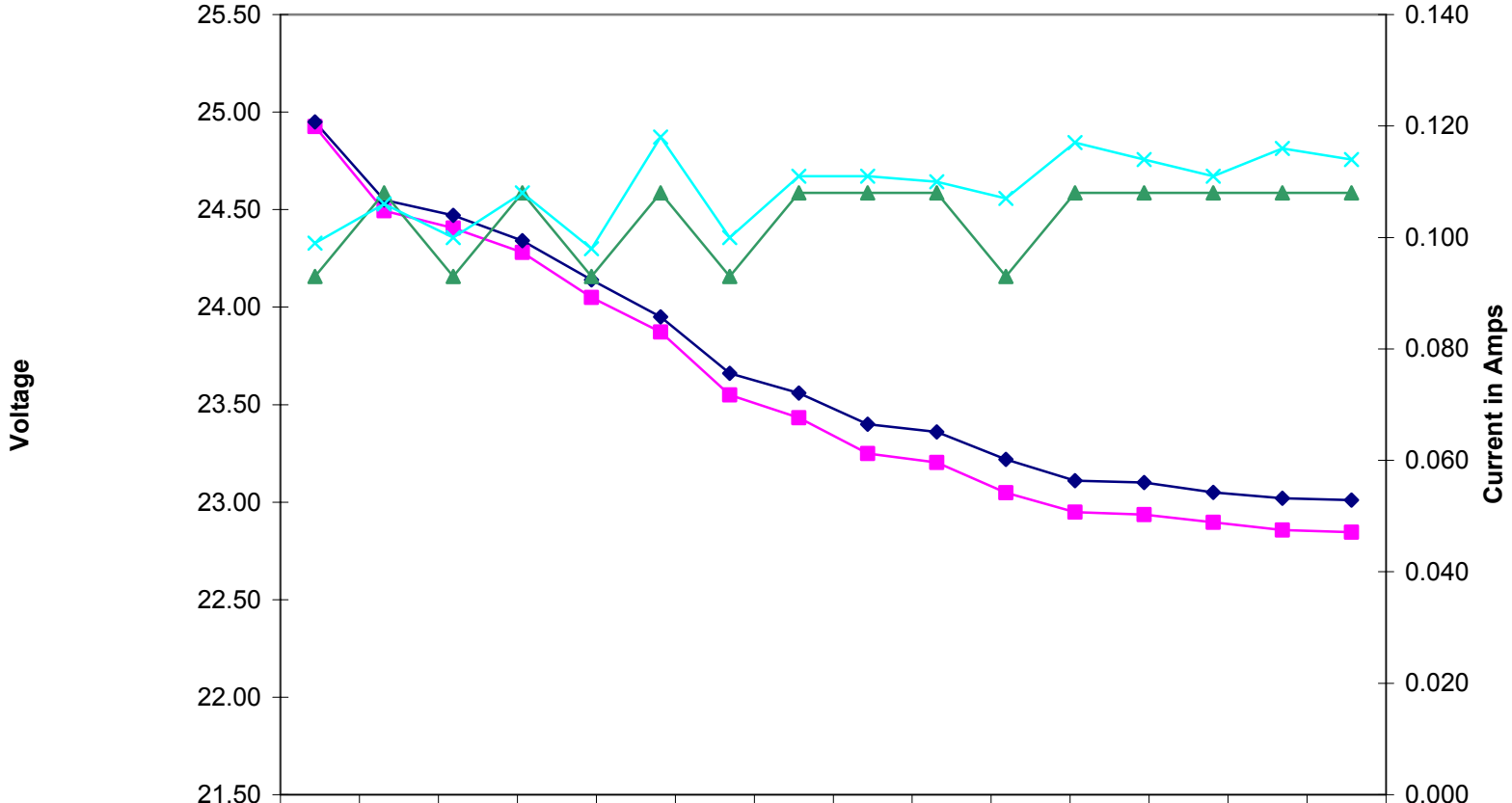
Gentex 14/12-2 using nominal voltage



	Device 1	Device 2	Device 4	Device 5	Device 6	Device 8	Device 9	Device 10	Device 12	Device 13	Device 14	Device 16
Calculated voltage at device	23.35	22.91	22.70	22.47	22.29	21.85	21.67	21.62	21.37	21.36	21.32	21.27
Actual measured voltage	24.95	24.55	24.34	24.14	23.95	23.56	23.40	23.36	23.11	23.10	23.05	23.01
Manufacturer listed current	0.093	0.108	0.108	0.093	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
Actual measured current	0.099	0.106	0.108	0.098	0.118	0.111	0.111	0.110	0.117	0.114	0.111	0.114

Project Name		Gentex (AFP-200 w/CBC - PL)				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14/12-2 (added devices to 14/12-1) Actual volt.				Standard Wire Resistance per 1000						
Notes		110 vac, solid tone, strobes not synched				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			25.58			When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			21			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current amp		1.653		Wire	Ohm's	Alternate Calculations						
Actual total current = 1.802				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	12	1.98		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.653	480	4.872	1.653	480	2.436
	Listed	from	Voltage			Actual	1.740	480	5.128	1.740	480	2.564
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Gentex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.093	100	24.93	0.65	2.56%	0.099	100	24.95	GXS			
Device 2	0.108	45	24.49	1.09	4.24%	0.106	45	24.55	GX-90S	Actual V drop of 2.57 / lump sum		
Device 3	0.093	10	24.41	1.17	4.59%	0.100	10	24.47	GXS	V drop of 5.13 = **+50% variation**:		
Device 4	0.108	15	24.28	1.30	5.08%	0.108	15	24.34	GX-90S	Actual V drop of 2.57 / load		
Device 5	0.093	30	24.05	1.53	5.98%	0.098	30	24.14	GXS	centering V drop of 2.56 = ***--0%***		
Device 6	0.108	25	23.87	1.71	6.68%	0.118	25	23.95	GX-90S	**variation**: using actual currents.		
Device 7	0.093	50	23.55	2.03	7.94%	0.100	50	23.66	GXS			
Device 8	0.108	20	23.43	2.15	8.40%	0.111	20	23.56	GX-90S			
Device 9	0.108	35	23.25	2.33	9.11%	0.111	35	23.40	GX-90S			
Device 10	0.108	10	23.20	2.38	9.29%	0.110	10	23.36	GX-90S			
Device 11	0.093	40	23.05	2.53	9.90%	0.107	40	23.22	GXS			
Device 12	0.108	30	22.95	2.63	10.28%	0.117	30	23.11	GX-90S			
Device 13	0.108	5	22.94	2.64	10.34%	0.114	5	23.10	GX-90S			
Device 14	0.108	20	22.90	2.68	10.49%	0.111	20	23.05	GX-90S			
Device 15	0.108	30	22.86	2.72	10.65%	0.116	30	23.02	GX-90S			
Device 16	0.108	15	22.85	2.73	10.69%	0.114	15	23.01	GX-90S			
END			22.85	2.73	10.69%							
END			22.85	2.73	10.69%							
END			22.85	2.73	10.69%							
END			22.85	2.73	10.69%							
Totals	1.653	480				1.740	480					
Actual voltage was 1% above calculated voltage.												

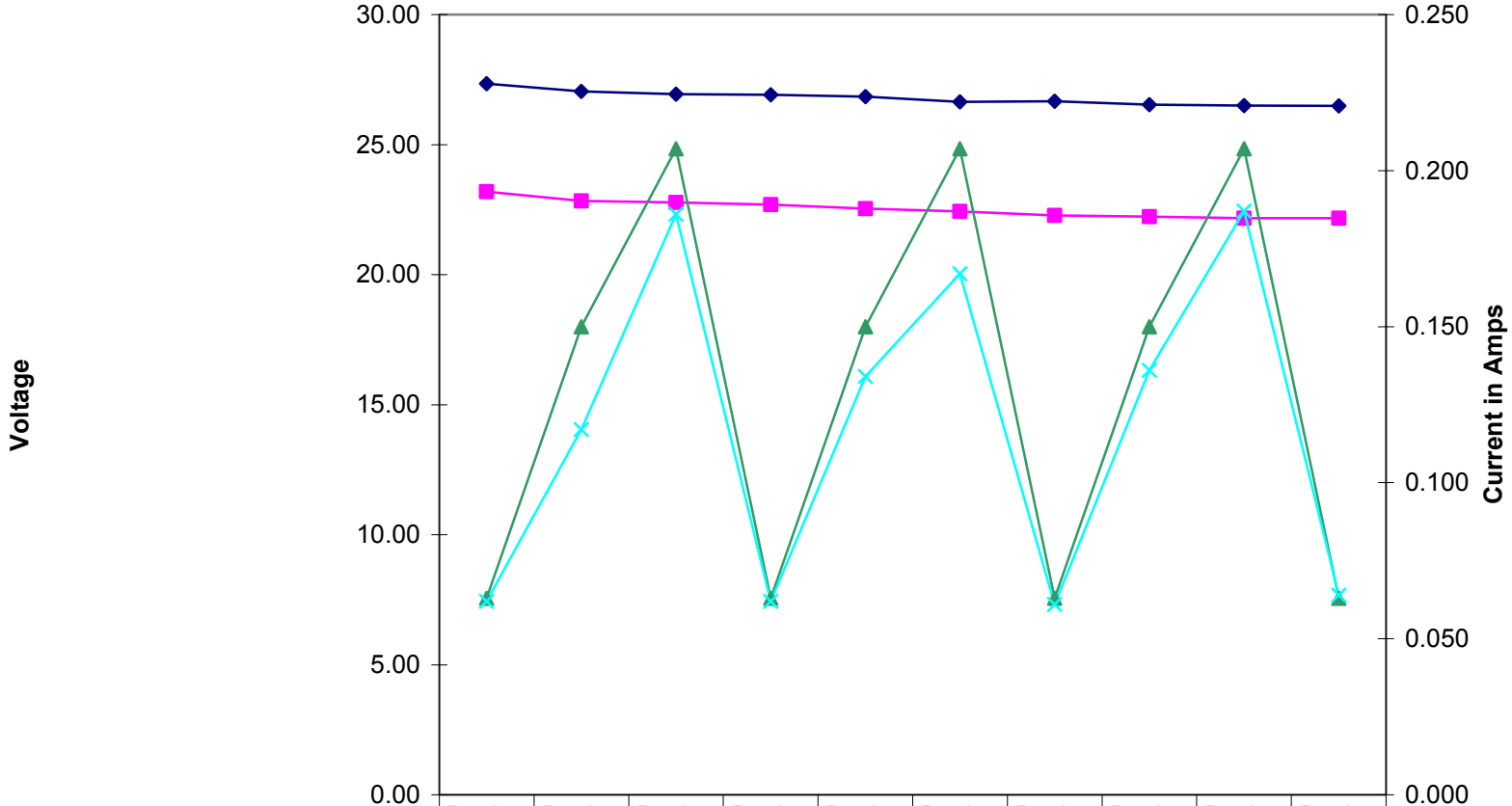
Gentex 14/12-2 using actual voltage (up to 1% variation)



	Device 1	Device 2	Device 3	Device 4	Device 6	Device 7	Device 8	Device 9	Device 10	Device 11	Device 12	Device 14	Device 15	Device 16
Calc. voltage	24.93	24.49	24.41	24.28	23.87	23.55	23.43	23.25	23.20	23.05	22.95	22.90	22.86	22.85
Actual voltage	24.95	24.55	24.47	24.34	23.95	23.66	23.56	23.40	23.36	23.22	23.11	23.05	23.02	23.01
Listed current	0.093	0.108	0.093	0.108	0.108	0.093	0.108	0.108	0.108	0.093	0.108	0.108	0.108	0.108
Actual current	0.099	0.106	0.100	0.108	0.118	0.100	0.111	0.111	0.110	0.107	0.117	0.111	0.116	0.114

Project Name		Simplex (Power supply =				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14-1				Standard Wire Resistance per 1000						
Notes		110 vac, solid tone, strobes not synched				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = 27.7		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			22			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.323		Wire	Ohm's	Alternate Calculations						
Total actual current = 1.160				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.323	340	2.762	1.323	340	1.381
	Listed	from	Voltage			Actual	1.176	340	2.455	1.176	340	1.228
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Simplex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.063	100	23.19	0.81	3.38%	0.062	100	27.34	4903-9425			
Device 2	0.150	45	22.84	1.16	4.84%	0.117	45	27.05	4903-9426			
Device 3	0.207	10	22.77	1.23	5.12%	0.186	10	26.94	4903-9427			
Device 4	0.063	15	22.69	1.31	5.47%	0.062	15	26.91	4903-9425			
Device 5	0.150	30	22.53	1.47	6.11%	0.134	30	26.85	4903-9426			
Device 6	0.207	25	22.43	1.57	6.55%	0.167	25	26.64	4903-9427			
Device 7	0.063	50	22.28	1.72	7.17%	0.061	50	26.67	4903-9425			
Device 8	0.150	20	22.23	1.77	7.38%	0.136	20	26.54	4903-9426			
Device 9	0.207	35	22.17	1.83	7.63%	0.187	35	26.50	4903-9427			
Device 10	0.063	10	22.17	1.83	7.64%	0.064	10	26.49	4903-9425			
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
Totals	1.323	340				1.176	340					

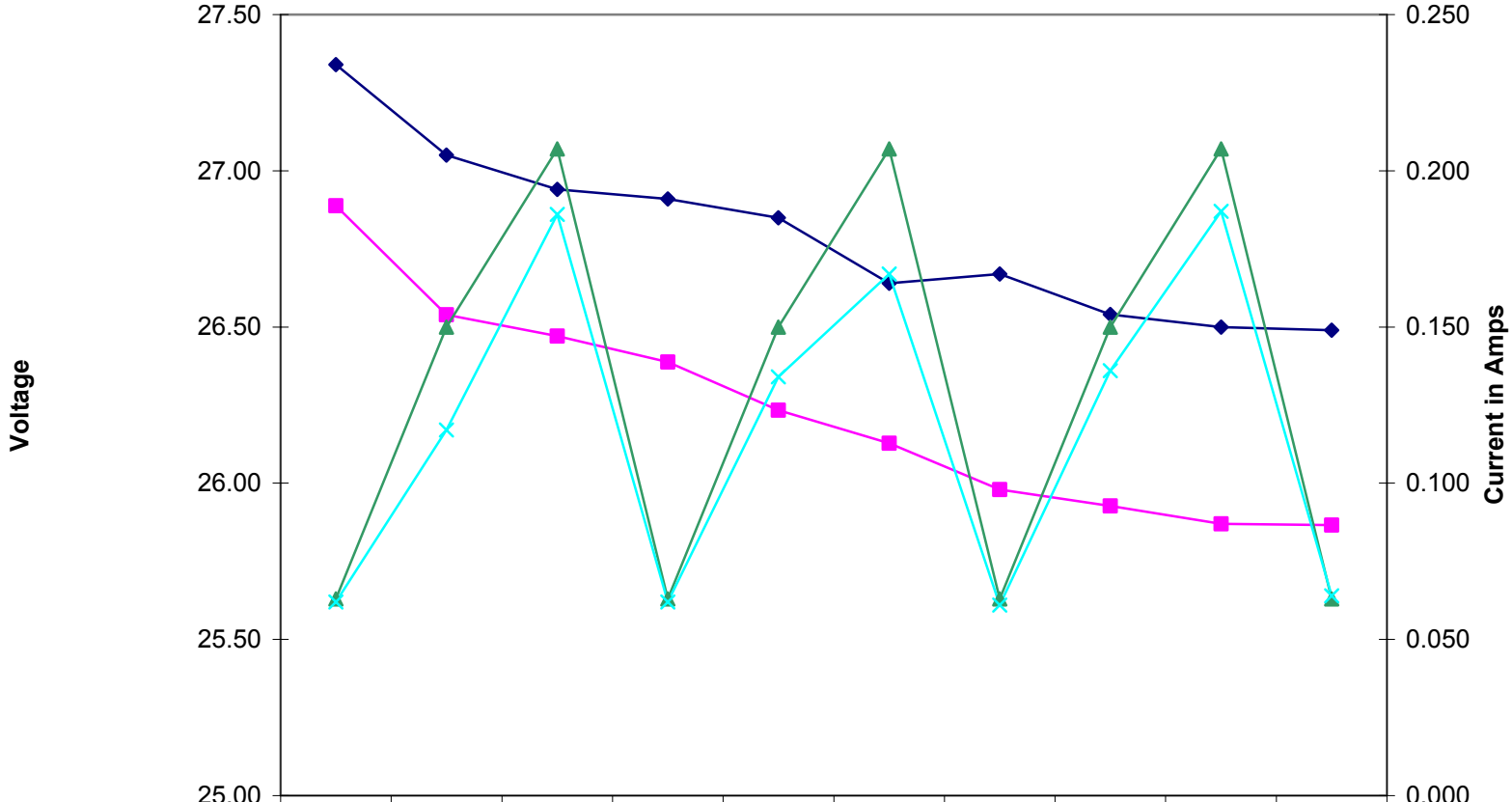
Simplex 14/1, using nominal voltage (look closely at scales)



	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10
Calculated voltage at device	23.19	22.84	22.77	22.69	22.53	22.43	22.28	22.23	22.17	22.17
Actual measured voltage	27.34	27.05	26.94	26.91	26.85	26.64	26.67	26.54	26.50	26.49
Manufacturer listed current	0.063	0.150	0.207	0.063	0.150	0.207	0.063	0.150	0.207	0.063
Actual measured current	0.062	0.117	0.186	0.062	0.134	0.167	0.061	0.136	0.187	0.064

Project Name		Simplex (Power supply =				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14-1 Using actual voltage				Standard Wire Resistance per 1000						
Notes		110 vac, solid tone, strobes not synched				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			27.7			When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			22			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.323		Wire	Ohm's	Alternate Calculations						
Total actual current = 1.160				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.323	340	2.762	1.323	340	1.381
	Listed	from	Voltage			Actual	1.176	340	2.455	1.176	340	1.228
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Simplex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.063	100	26.89	0.81	2.93%	0.062	100	27.34	4903-9425			
Device 2	0.150	45	26.54	1.16	4.19%	0.117	45	27.05	4903-9426	Actual V drop of 1.21 / lump sum		
Device 3	0.207	10	26.47	1.23	4.44%	0.186	10	26.94	4903-9427	V drop of 2.46 = **+51% variation**:		
Device 4	0.063	15	26.39	1.31	4.74%	0.062	15	26.91	4903-9425	Actual V drop of 1.21 / load		
Device 5	0.150	30	26.23	1.47	5.29%	0.134	30	26.85	4903-9426	centering V drop of 1.23 = **+2%**		
Device 6	0.207	25	26.13	1.57	5.68%	0.167	25	26.64	4903-9427	**variation**: using actual currents.		
Device 7	0.063	50	25.98	1.72	6.21%	0.061	50	26.67	4903-9425			
Device 8	0.150	20	25.93	1.77	6.40%	0.136	20	26.54	4903-9426			
Device 9	0.207	35	25.87	1.83	6.61%	0.187	35	26.50	4903-9427			
Device 10	0.063	10	25.87	1.83	6.62%	0.064	10	26.49	4903-9425			
END			25.87	1.83	6.62%							
END			25.87	1.83	6.62%							
END			25.87	1.83	6.62%							
END			25.87	1.83	6.62%							
END			25.87	1.83	6.62%							
END			25.87	1.83	6.62%							
END			25.87	1.83	6.62%							
END			25.87	1.83	6.62%							
END			25.87	1.83	6.62%							
END			25.87	1.83	6.62%							
Totals	1.323	340				1.176	340					
Actual voltage was 2% above calculated.												

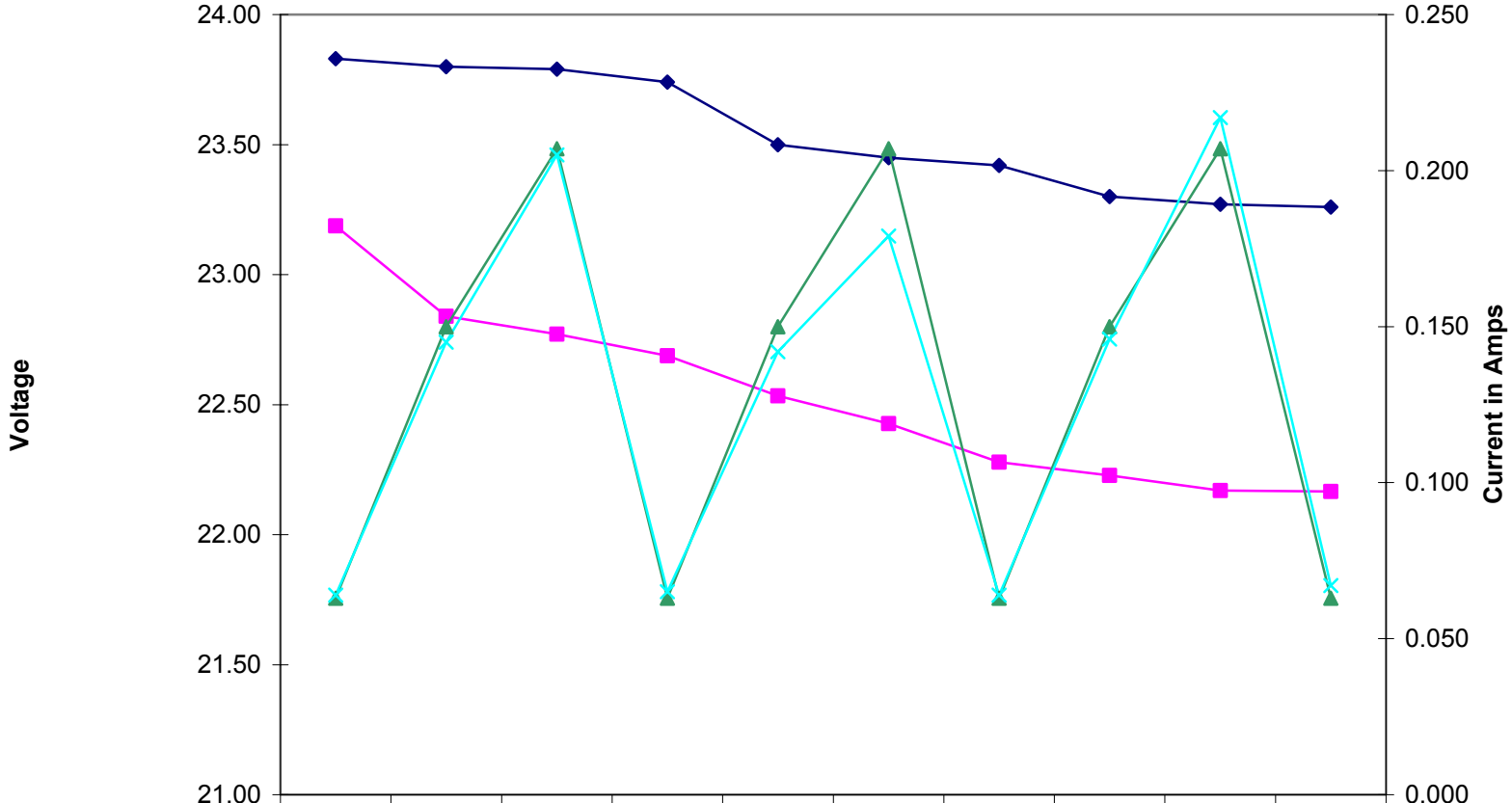
Simplex 14-1 using actual voltage (2 %variation) (look closely at scales)



	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10
Calc. voltage	26.89	26.54	26.47	26.39	26.23	26.13	25.98	25.93	25.87	25.87
Actual voltage	27.34	27.05	26.94	26.91	26.85	26.64	26.67	26.54	26.50	26.49
Listed current	0.063	0.150	0.207	0.063	0.150	0.207	0.063	0.150	0.207	0.063
Actual current	0.062	0.117	0.186	0.062	0.134	0.167	0.061	0.136	0.187	0.064

Project Name		Simplex (Power supply =				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14-3				Standard Wire Resistance per 1000						
Notes		**battery, not synched**				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = see notes		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			22			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.323		Wire	Ohm's	Alternate Calculations						
Actual total current = see notes				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.323	340	2.762	1.323	340	1.381
	Listed	from	Voltage			Actual	1.294	340	2.701	1.294	340	1.351
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Simplex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.063	100	23.19	0.81	3.38%	0.064	100	23.83	4903-9425			
Device 2	0.150	45	22.84	1.16	4.84%	0.145	45	23.80	4903-9426			
Device 3	0.207	10	22.77	1.23	5.12%	0.205	10	23.79	4903-9427			
Device 4	0.063	15	22.69	1.31	5.47%	0.065	15	23.74	4903-9425			
Device 5	0.150	30	22.53	1.47	6.11%	0.142	30	23.50	4903-9426			
Device 6	0.207	25	22.43	1.57	6.55%	0.179	25	23.45	4903-9427			
Device 7	0.063	50	22.28	1.72	7.17%	0.064	50	23.42	4903-9425			
Device 8	0.150	20	22.23	1.77	7.38%	0.146	20	23.30	4903-9426			
Device 9	0.207	35	22.17	1.83	7.63%	0.217	35	23.27	4903-9427			
Device 10	0.063	10	22.17	1.83	7.64%	0.067	10	23.26	4903-9425			
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
END			22.17	1.83	7.64%							
Totals	1.323	340				1.294	340					
Notes: Start voltage 24.29 at 1.29A, mid 24.46 volts at 1.28A, end 24.44 volts at 1.28A.												

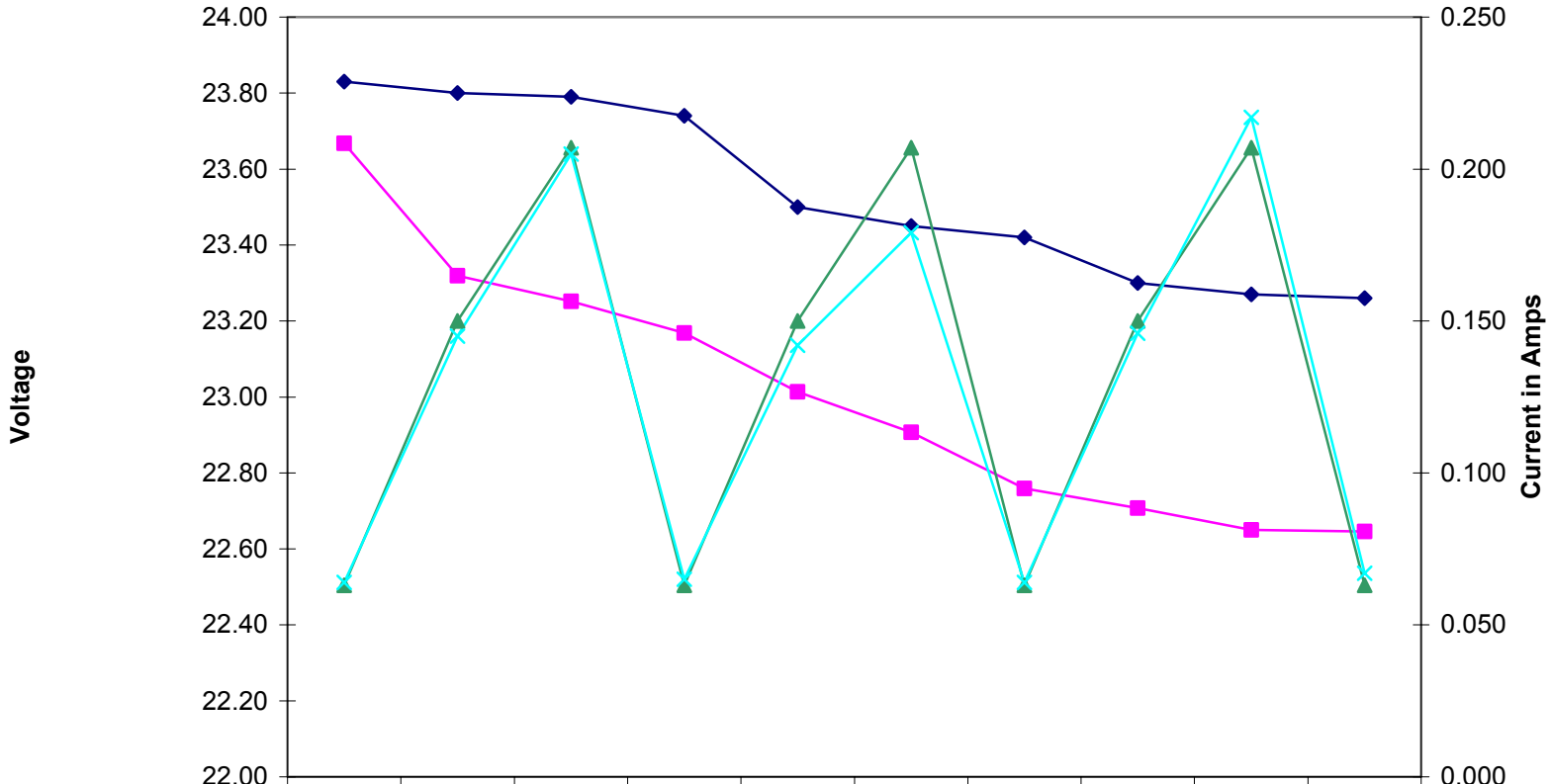
Simplex 14/3, using nominal voltage (look closely at scales)



	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10
Calc. voltage	23.19	22.84	22.77	22.69	22.53	22.43	22.28	22.23	22.17	22.17
Actual voltage	23.83	23.80	23.79	23.74	23.50	23.45	23.42	23.30	23.27	23.26
Listed current	0.063	0.150	0.207	0.063	0.150	0.207	0.063	0.150	0.207	0.063
Actual current	0.064	0.145	0.205	0.065	0.142	0.179	0.064	0.146	0.217	0.067

Project Name		Simplex (Power supply =				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14-3 using actual voltage				Standard Wire Resistance per 1000						
Notes		**battery, not synched**				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			24.48	Actual = **see notes**		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			22			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current	1.323			Wire	Ohm's	Alternate Calculations						
Actual total current = see notes				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	14	3.07		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.323	340	2.762	1.323	340	1.381
	Listed	from		Voltage		Actual	1.294	340	2.701	1.294	340	1.351
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Simplex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.063	100	23.67	0.81	3.32%	0.064	100	23.83	4903-9425			
Device 2	0.150	45	23.32	1.16	4.74%	0.145	45	23.80	4903-9426	Actual V drop of 1.22 / lump sum		
Device 3	0.207	10	23.25	1.23	5.02%	0.205	10	23.79	4903-9427	V drop of 2.70 = **+55% variation**:		
Device 4	0.063	15	23.17	1.31	5.36%	0.065	15	23.74	4903-9425	Actual V drop of 1.22 / load		
Device 5	0.150	30	23.01	1.47	5.99%	0.142	30	23.50	4903-9426	centering V drop of 1.35 = **+10%**		
Device 6	0.207	25	22.91	1.57	6.42%	0.179	25	23.45	4903-9427	**variation**: using actual currents.		
Device 7	0.063	50	22.76	1.72	7.03%	0.064	50	23.42	4903-9425			
Device 8	0.150	20	22.71	1.77	7.24%	0.146	20	23.30	4903-9426			
Device 9	0.207	35	22.65	1.83	7.48%	0.217	35	23.27	4903-9427			
Device 10	0.063	10	22.65	1.83	7.49%	0.067	10	23.26	4903-9425			
END			22.65	1.83	7.49%							
END			22.65	1.83	7.49%							
END			22.65	1.83	7.49%							
END			22.65	1.83	7.49%							
END			22.65	1.83	7.49%							
END			22.65	1.83	7.49%							
END			22.65	1.83	7.49%							
END			22.65	1.83	7.49%							
END			22.65	1.83	7.49%							
END			22.65	1.83	7.49%							
Totals	1.323	340				1.294	340					
Actual voltage was 1% over calculated at beginning, 2% in middle and 3% over at end of test. Based on beginning voltage used.												
Notes: Start voltage 24.29 at 1.29A, mid 24.46 volts at 1.28A, end 24.44 volts at 1.28A. Used 24.48 for starting voltage in calcs.												

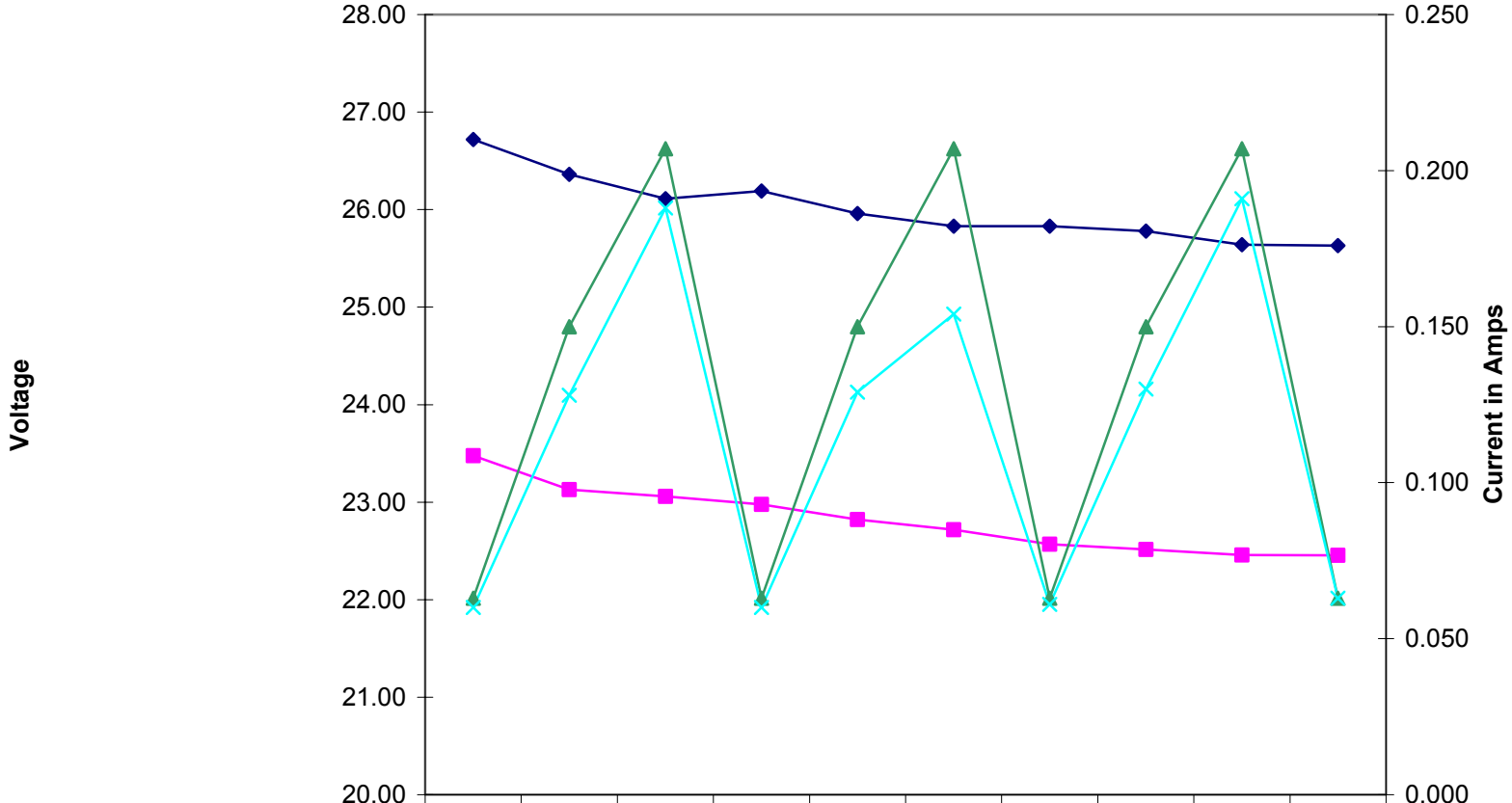
Simplex 14-3, battery, using actual voltage (1% - 3% variation) (look closely at scales)



	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10
Calc. voltage	23.67	23.32	23.25	23.17	23.01	22.91	22.76	22.71	22.65	22.65
Actual voltage	23.83	23.80	23.79	23.74	23.50	23.45	23.42	23.30	23.27	23.26
Listed current	0.063	0.150	0.207	0.063	0.150	0.207	0.063	0.150	0.207	0.063
Actual current	0.064	0.145	0.205	0.065	0.142	0.179	0.064	0.146	0.217	0.067

Project Name		Simplex (Power supply =				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14/12-1				Standard Wire Resistance per 1000						
Notes		110 vac, solid tone, **not synched**				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Nominal System Voltage			24	Actual = 26.94		When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			22			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.323		Wire	Ohm's	Alternate Calculations						
Actual total current = 1.182				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	12	1.98		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.323	340	2.762	1.323	340	1.381
	Listed	from	Voltage			Actual	1.164	340	2.430	1.164	340	1.215
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:	Simplex		
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.063	100	23.48	0.52	2.18%	0.060	100	26.72	4903-9425			
Device 2	0.150	45	23.13	0.87	3.63%	0.128	45	26.36	4903-9426			
Device 3	0.207	10	23.06	0.94	3.92%	0.188	10	26.11	4903-9427			
Device 4	0.063	15	22.98	1.02	4.26%	0.060	15	26.19	4903-9425			
Device 5	0.150	30	22.82	1.18	4.91%	0.129	30	25.96	4903-9426			
Device 6	0.207	25	22.72	1.28	5.35%	0.154	25	25.83	4903-9427			
Device 7	0.063	50	22.57	1.43	5.97%	0.061	50	25.83	4903-9425			
Device 8	0.150	20	22.52	1.48	6.18%	0.130	20	25.78	4903-9426			
Device 9	0.207	35	22.46	1.54	6.42%	0.191	35	25.64	4903-9427			
Device 10	0.063	10	22.45	1.55	6.44%	0.063	10	25.63	4903-9425			
END			22.45	1.55	6.44%							
END			22.45	1.55	6.44%							
END			22.45	1.55	6.44%							
END			22.45	1.55	6.44%							
END			22.45	1.55	6.44%							
END			22.45	1.55	6.44%							
END			22.45	1.55	6.44%							
END			22.45	1.55	6.44%							
END			22.45	1.55	6.44%							
END			22.45	1.55	6.44%							
Totals	1.323	340				1.164	340					

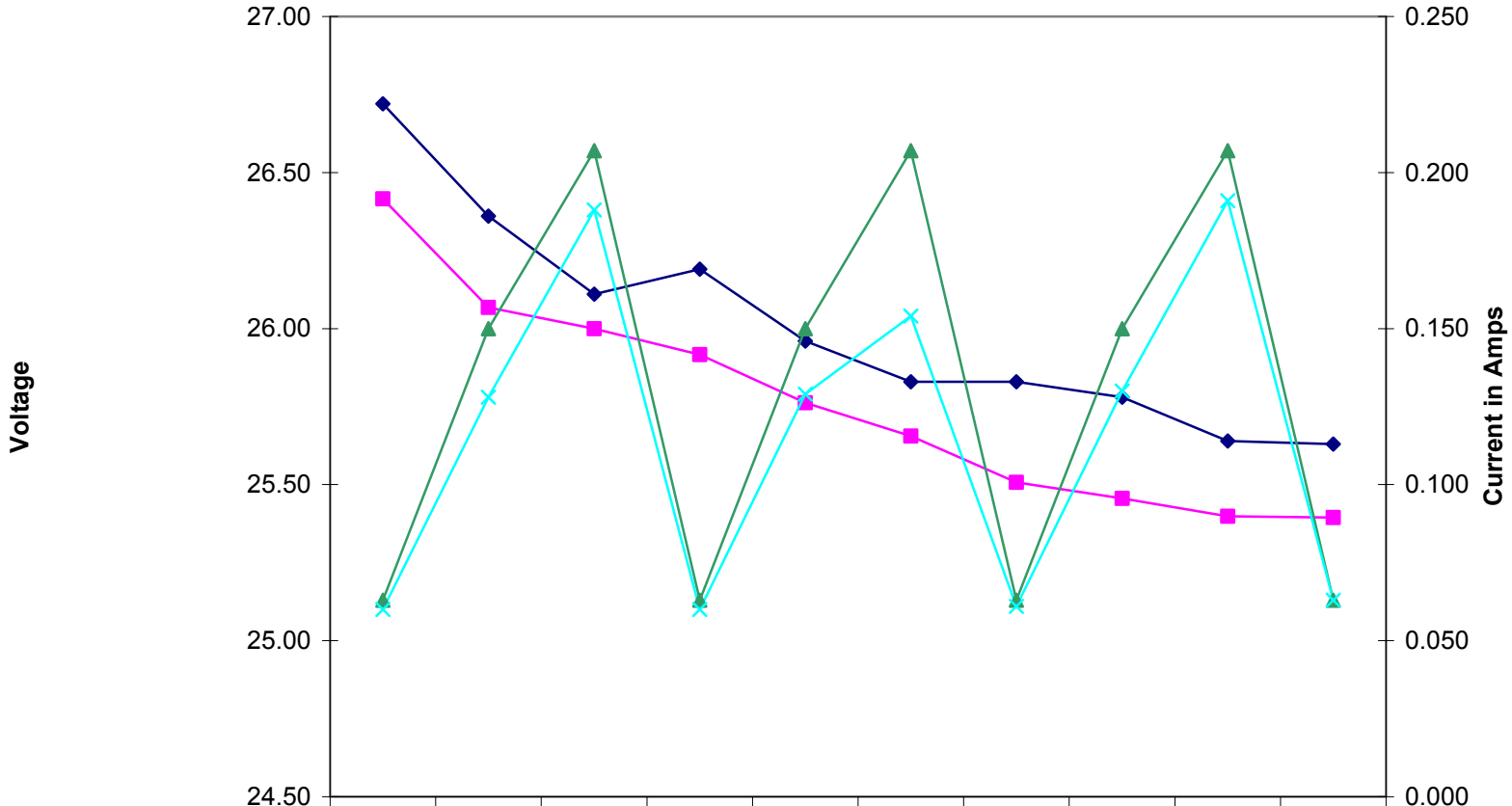
Simplex 14/12-1, using nominal voltage (look closely at scales)



	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10
Calculated voltage	23.48	23.13	23.06	22.98	22.82	22.72	22.57	22.52	22.46	22.45
Actual measured voltage	26.72	26.36	26.11	26.19	25.96	25.83	25.83	25.78	25.64	25.63
Manufacturer listed current	0.063	0.150	0.207	0.063	0.150	0.207	0.063	0.150	0.207	0.063
Actual measured current	0.060	0.128	0.188	0.060	0.129	0.154	0.061	0.130	0.191	0.063

Project Name		Simplex (Power supply =				**POINT-POINT LIMITS MEET**						
Date												
Circuit Number		14/12-1 **Using actual voltage**				Standard Wire Resistance per 1000						
Notes		110 vac, solid tone, **not synched**				18=7.77	16=4.89	14=3.07	12=1.98	10=1.24		
Actual System Voltage			26.94			When entering your measured value. Use the resistance measured for						
Minimum Device Voltage			22			one way on the circuit or 1/2 the total resistance out and back						
Total Circuit Current		1.323		Wire	Ohm's	Alternate Calculations						
Actual total current = 1.182				Gauge	Per 1000		Lump-Sum Method			Load Centering Method		
Distance from source to 1st device			100	12	1.98		Totals		Voltage	Totals		Voltage
Wire Gauge for balance of circuit				14	3.07		Current	Distance	Drop	Current	Distance	Drop
		Distance				Calculated	1.323	340	2.762	1.323	340	1.381
	Listed	from		Voltage		Actual	1.164	340	2.430	1.164	340	1.215
Device	Device	previous	At	Drop from	Percent	Actual Measurements			Device Manufacture:		Simplex	
Number	Current	device	Device	source	Drop	Current	Distance	Voltage	Model Numbers:			
Device 1	0.063	100	26.42	0.52	1.94%	0.060	100	26.72	4903-9425			
Device 2	0.150	45	26.07	0.87	3.24%	0.128	45	26.36	4903-9426	Actual V drop of 1.31 / lump sum		
Device 3	0.207	10	26.00	0.94	3.49%	0.188	10	26.11	4903-9427	V drop of 2.43 = **+46% variation**:		
Device 4	0.063	15	25.92	1.02	3.80%	0.060	15	26.19	4903-9425	Actual V drop of 1.31 / load		
Device 5	0.150	30	25.76	1.18	4.37%	0.129	30	25.96	4903-9426	centering V drop of 1.22 = **+7%**		
Device 6	0.207	25	25.66	1.28	4.77%	0.154	25	25.83	4903-9427	**variation**: using actual currents.		
Device 7	0.063	50	25.51	1.43	5.32%	0.061	50	25.83	4903-9425			
Device 8	0.150	20	25.46	1.48	5.51%	0.130	20	25.78	4903-9426			
Device 9	0.207	35	25.40	1.54	5.72%	0.191	35	25.64	4903-9427			
Device 10	0.063	10	25.39	1.55	5.74%	0.063	10	25.63	4903-9425			
END			25.39	1.55	5.74%							
END			25.39	1.55	5.74%							
END			25.39	1.55	5.74%							
END			25.39	1.55	5.74%							
END			25.39	1.55	5.74%							
END			25.39	1.55	5.74%							
END			25.39	1.55	5.74%							
END			25.39	1.55	5.74%							
END			25.39	1.55	5.74%							
END			25.39	1.55	5.74%							
Totals	1.323	340				1.164	340					
Actual voltage was 1% above calculated voltage.												

Simplex 14/12-1 using actual voltage (1% variation) (look closely at scales)



	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6	Device 7	Device 8	Device 9	Device 10
Calculated voltage	26.42	26.07	26.00	25.92	25.76	25.66	25.51	25.46	25.40	25.39
Measured voltage	26.72	26.36	26.11	26.19	25.96	25.83	25.83	25.78	25.64	25.63
Listed Current	0.063	0.150	0.207	0.063	0.150	0.207	0.063	0.150	0.207	0.063
Actual current	0.060	0.128	0.188	0.060	0.129	0.154	0.061	0.130	0.191	0.063

Test Procedures:

Most of our tests were conducted in a controlled environment. A 4' x 8' piece of 1/2" plywood was mounted vertically onto an inverted "T" base frame. 4" square mud rings (normally used on 4" x 4" electrical boxes) were mounted on one half (4'x4') of the plywood. The center of the mud rings was then cut out to allow for mounting of the notification devices. The second half of the plywood was used to mount the control/power panels. A 1,000' spool of 14 AWG FPL wire, a 500' spool of 18 AWG FPL wire, and 12 AWG THHN were pre-cut and labeled into various lengths (5', 10', 15', 20', etc.). After reviewing miscellaneous previously permitted fire alarm plans, various wiring scenarios were established. To assure that electromagnetic fields did not affect the wire resistance, all circuit wiring was stretched out (was rolled up for storage).

The tests were conducted inside of a small air-conditioned warehouse. We wanted to make sure that the environmental temperature of the tests were representative of the average alarmed building. Temperature has an impact on the resistance of the wire, and can have an effect on device and battery performance. Because this space consisted of brick walls and concrete floors, a heavyweight flannel sleeping bag was draped over the devices once they were mounted. This significantly reduced the sound level and limited strobe flashes for the individuals conducting the large number of tests. Ear Muff hearing protection was also used. Fire alarm power supplies were pig-tailed and plugged into standard, non-isolated receptacles for the test. A Radio Shack model 22-186A LCD digital multimeter was used to monitor voltage, while a Craftsman model 82026 LCD digital multimeter was used to monitor current.

Once the circuit was calculated based on the point-to-point drop, the test circuit was assembled on the test board. The actual results were then taken reading the current and voltage simultaneously at each device. "T" tapped circuits were used in many cases at the devices to facilitate better control of the measurements (understanding that this wiring method is not allowed by code due to supervisory reasons, but had no detectable impact on our voltage or current readings). Approximately four inches of 14 AWG wire was used for the taps.

Two field studies within existing buildings were conducted. The high school was about one year old, while the telecommunication facility was new. <u>As of this first draft, these results have not been finalized or charted.</u>